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MEASUREMENTS

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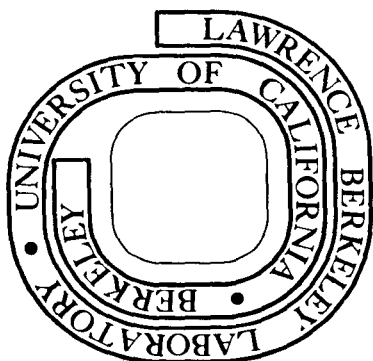
John W. Morse and James J. Zullig

September 1980

Prepared for the U.S. Department of Energy
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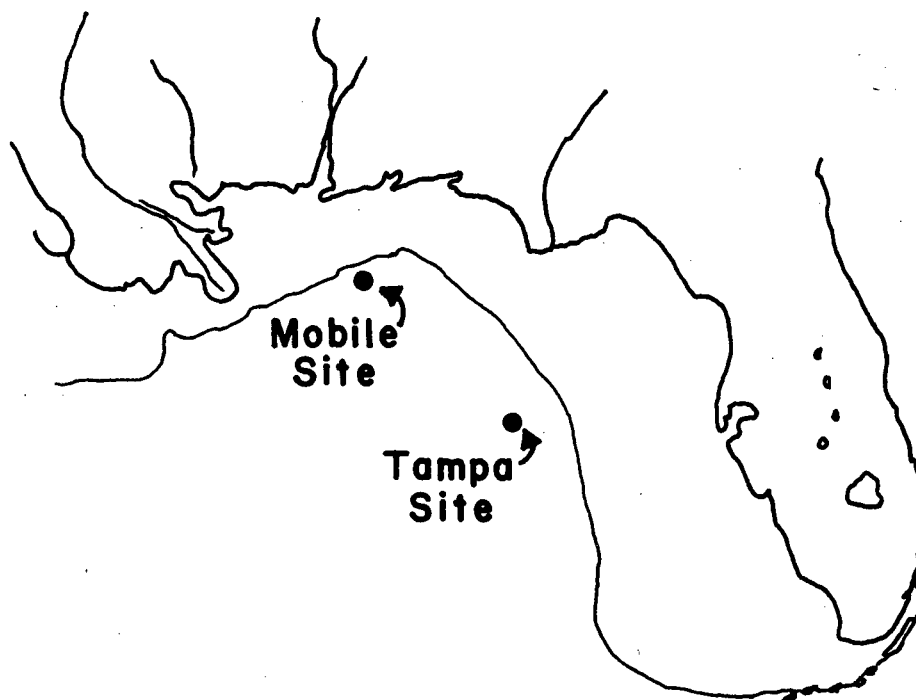
**OTEC
GULF OF MEXICO
OXYGEN AND NUTRIENT
MEASUREMENTS**

June 1978 - June 1979

John W. Morse and James J. Zullig

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**Subcontract 4984002
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**Prepared for the U.S. Department of Energy
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ABSTRACT

As part of the Ocean Thermal Energy Conversion (OTEC) Program, oceanic regions with a high potential for OTEC plant siting are being carefully studied in order to establish baseline data on oceanic parameters of importance to plant design and of environmental concern. Among these parameters are chlorophyll and ATP, which are indicators of biological activity and dissolved nutrients and oxygen. By combining these parameters with others, on a time series basis, the dynamics of the complex behavior of the ocean at potential OTEC sites can be established to the degree necessary for initial plant design and siting considerations.

This report presents the results obtained at the University of Miami, during our participation in the study of the eastern Gulf of Mexico (GOTEC), during the last 14 months. The first part of this report presents a detailed explanation of the collection, preservation and analytical techniques which we have used. For each of the two sites (Mobile and Tampa) which were repeatedly occupied, a data summary sheet and concentration versus depth plots of oxygen, nitrate, ammonia, reactive phosphate, total phosphorus and silica are provided for each of the cruises made to these sites. Although we collected and preserved chlorophyll and ATP samples, the analytical work was not done here and, consequently, no data on their concentrations are presented. Also presented are composite plots, which contain all the data for a given parameter, and comparisons of "reactive" phosphate to both total phosphorus and nitrate. No attempt has been made to interpret these results, as such an interpretation must be made in combination with other important oceanographic parameters measured at these sites, such as temperature, salinity, currents and biological information.

I. SHIPBOARD PROCEDURES

A. ATP and Chlorophyll^{*}

At both the Mobile and Tampa sites two casts were made on most cruises. The first cast was to 300 meters for the purpose of collecting chlorophyll and ATP samples. Twelve samples were retrieved from each of the 5 liter Niskin bottles. In addition, a surface sample was obtained, bringing the total number of samples for each station and for each analysis to thirteen. The total time lapse from sampling to preservation for the 300 meter cast was approximately two hours. This can be reduced in the future by the use of a larger number of filtering manifolds, since the filtration must be done at 1/4 to 1/3 atm, to prevent pigment from being pulled through the filter for the chlorophyll analysis (Strickland and Parsons, 1972).

The ATP preservation entailed the filtration of 1 liter from each sampler on 4.5 cm Whatman GF/C glass filters. At the same time 1 ml aliquots of a tris buffer solution (2.5 g of tris hydroxymethyl amino methane, m/l H_2O) were kept boiling in test tubes in a water bath. As soon as filtration was complete (no more than 15 seconds) the filter was placed in one of the tubes containing tris buffer and placed in the boiling bath for two minutes. Finally, the tris buffer and filter were sealed in a whirl-pack bag and frozen.

Two liters from each sampler were used for each chlorophyll analysis. The samples were filtered on 4.5 cm Whatman GF/C glass filters and 1 ml

* Analyses of ATP and chlorophyll were performed at Lawrence Berkeley Laboratory.

of a MgCO_3 slurry was placed in the sample prior to filtration. Upon completion of filtration, the filter was immediately placed in a whirl-pack bag and frozen.

B. Oxygen and Nutrients

The second cast made at each station was generally to approximately 1000 meters and was for the purpose of collecting samples for total phosphorus, ammonia, nutrient (NO_3^- , NO_2^- , SiO_3 and PO_4^{-3}), and dissolved oxygen analyses. The total time elapsed for the 1000 meter cast was approximately twenty minutes. The O_2 samples were taken as soon as the Niskin bottles were retrieved from the wire. The O_2 samples were preserved by a) rinsing and overflowing several times the 125 ml brown glass sample bottle, and b) preserving with 1 ml MnCl_2 (528 g $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}/\ell$) and 1 ml NaI - NaOH solutions. The bottle was completely filled and capped (allowing no air to enter) (135 g NaI and 499 g NaOH/ℓ) and shaken vigorously several times. The glass bottles were then placed in plastic containers which were subsequently filled with surface seawater, capped and stored in a cold and dark place.

The total phosphorus samples were placed in 125 ml glass Erlenmeyer flasks (rinsed 2X with sample) and capped with saran-wrap covered rubber stoppers. The samples were stored in a cold and dark place. The ammonia samples were syringe filtered using 47 mm Nucleopore 0.4 μm filter membranes, and placed in 125 ml brown glass bottles to which 5 ml of phenol solution (10 g phenol/100 ethanol). The samples were then frozen.

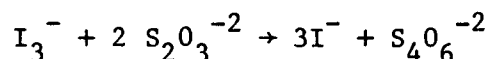
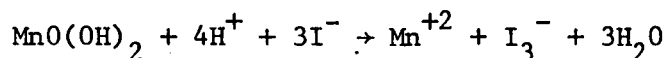
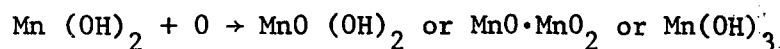
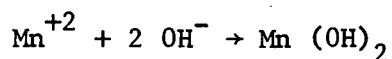
The samples for the nutrient analysis were syringe filtered, as in the ammonia analysis, and placed in 125 ml plastic bottles (linear polyethylene) and preserved with three drops of HgCl_2 (5.2 g HgCl_2 /1000 ml distilled H_2O). The samples were then frozen.

II. LABORATORY ANALYSIS

During the June, 1978 to June, 1979 period the techniques used for the nutrient analysis conducted on the auto analyzer (i.e., NO_3^- , NO_2^- , SiO_3 , and PO_4^{-3}) were modified. All work done under what will be called "old techniques" will include all data up to December, 1978. From January, 1979 all the work on the auto analyzer was done using the updated methods which will be referred to as the "new techniques." The changes made will be outlined in the course of this section.

A. Oxygen

Oxygen was analyzed by the classical Winkler method (Winkler, 1898). Essentially, a divalent manganese solution (MnCl_2), followed by strong alkalai solution (NaI - NaOH) is added to the sample (done on board ship). A manganese hydroxide precipitate is formed in the sealed bottle. Any dissolved O_2 rapidly oxidizes an equivalent amount of divalent manganese to basic hydroxides of higher valency states. When the solution is acidified in the presence of iodide, the oxidized manganese is reduced to the divalent state and iodine, equivalent to the original dissolved O_2 content of the water, is liberated. The iodine is titrated with standardized thio-sulphate solution using a starch indicator. The reaction is summarized below.



The detection limit was 0.056 ml O_2/ℓ seawater. The standard deviation for waters containing 5.00 ml O_2/ℓ were typically ± 0.030 ml O_2/ℓ .

Although this technique was used in all the GOTECH work, we recommend for future studies the use of a modified version of the Winkler method as outlined by Carpenter (1965a). The reason for this is that there are several errors introduced in using the old method which can reduce accuracy (Carpenter, 1965b).

B. Total Phosphorus

The method of manual analysis used for total phosphorus was the procedure outlined by Hansen and Robinson (1953). First, 50 ml of sample was evaporated with perchloric acid. The chloride was replaced by perchlorate and much of the arsenic was then volatilized. The residue was heated and any organic matter oxidized, liberating phosphorus as orthophosphate. 50 ml of water was added and the total phosphorus was determined manually as in the updated reactive phosphate procedure outlined later on in this section. The detection limit for this technique was $0.03 \mu\text{M PO}_4^{-3}$ -P/ ℓ . The standard deviation in 0.50 to $2.5 \mu\text{M PO}_4^{-3}$ -P/ ℓ range was typically ± 0.040 to ± 0.065 .

C. Ammonia

Ammonic was done manually according to the procedure outlined by Solorzano (1969). Seawater was treated in an alkaline citrate medium with sodium hypochlorite and phenol (added on board ship) in the presence of sodium nitro prusside, a catalyst. A blue indophenol complex was formed with ammonia and the extinction measured at 640 nm. The detection limit was $0.1 \mu\text{M NH}_3\text{-N/l}$ and the standard deviation for ammonia in the 1.0 to $3.0 \mu\text{M NH}_3\text{-N/l}$ range was typically ± 0.05 to $\pm 0.075 \mu\text{M NH}_3\text{-N/l}$.

D. General Nutrient, (NO_3^- , NO_2^- , SiO_3 , PO_4^{-3})

The nutrients (NO_3^- , NO_2^- , SiO_3 and PO_4^{-3}) were all done on a Technichon (CSM-6) autoanalyzer. The only modification made in the nitrate (NO_3^-) analytical method after December, 1978 was the use of a 550 nm instead of a 520 nm interference filter. This wavelength was found to be more sensitive for NO_3^- . The technique used was by Wood, Armstrong, and Richards (1967) as automated by Grasshoff (1976). NO_3^- was reduced quantitatively to NO_2^- by passing sample through a cadmium-copper reduction column. The NO_2^- produced was determined by diazotization with sulphanilamide and coupling with N-(1-nap)-ethylene-diamine to form a pink azo dye. Detection limits were $0.05 \mu\text{M NO}_3^- \text{-N/l}$ and the standard deviation in the range of 0.50 to $22.0 \mu\text{M NO}_3^- \text{-N/l}$ was ± 0.090 to $\pm 0.85 \text{ M NO}_3^- \text{-N/l}$.

The only modification made in December for the nitrite (NO_2^-) analysis was the same as NO_3^- (i.e., change of interference filter from 520 to 550 nm). The procedure used was the classic Griess reaction as applied to seawater by Bendschneider and Robinson (1952) and as automated by Grasshoff (1976).

NO_2^- reacts with sulphanilamide in an acid solution. The resultant diazo compound reacted with N- (1-naphthyl)-ethylene diamine and yields a highly colored pink azo dye. The detection limit was $0.01 \mu\text{M NO}_2^-$ -N/l. The standard deviation for the concentration range of 0.30 to $1.0 \mu\text{M NO}_2^-$ -N/l was ± 0.012 to $\pm 0.016 \mu\text{M NO}_2^-$ -N/l.

The method of silicate analysis was not modified during the course of the year. The procedure followed was by Chow and Robinson (1953) as automated by Grasshoff (1976). When seawater reacts with molybdate, silico molybdate, arsenomolybdate and phosphormolybdate are formed. A reducing solution, with Elon and oxalic acid is added. This results in the reduction of the silico molybdate complex to a blue heteropoly acid and also decomposes any phosphomolybdate and arsenomolybdate which eliminates interference. The detection limit for this technique was $0.5 \mu\text{M SiO}_3^-$ -Si/l and standard deviation for the range of 10 to $100 \mu\text{M SiO}_3^-$ -Si/l were typically $\pm 1.3\%$.

Two techniques were used for reactive phosphate (PO_4^{3-}). The old technique was outlined by Brewer, Chan and Riley (1965) and automated by the Technichon Company (Indust. Method 36-69W). The new technique employed was recommended by Grasshoff (1976) and originated with the technique of Murphy and Riley (1962). The old technique was slower because it used a heating coil for accelerating color development, as opposed to a trivalent antimony catalyst used in the Grasshoff (1976) technique. The catalyst increases the time of formation of blue heteropoly acid from seawater, molybdic acid, and ascorbic acid. The old

technique had a detection limit of $0.05 \mu\text{M PO}_4^{-3}$ -P/l as opposed to $0.02 \mu\text{M PO}_4^{-3}$ -P/l for the new technique. Standard deviations for the new technique in the range of 0.3 to $3.0 \mu\text{M PO}_4^{-3}$ -P/l were ± 0.01 to $\pm 0.015 \mu\text{M PO}_4^{-3}$ -P/l.

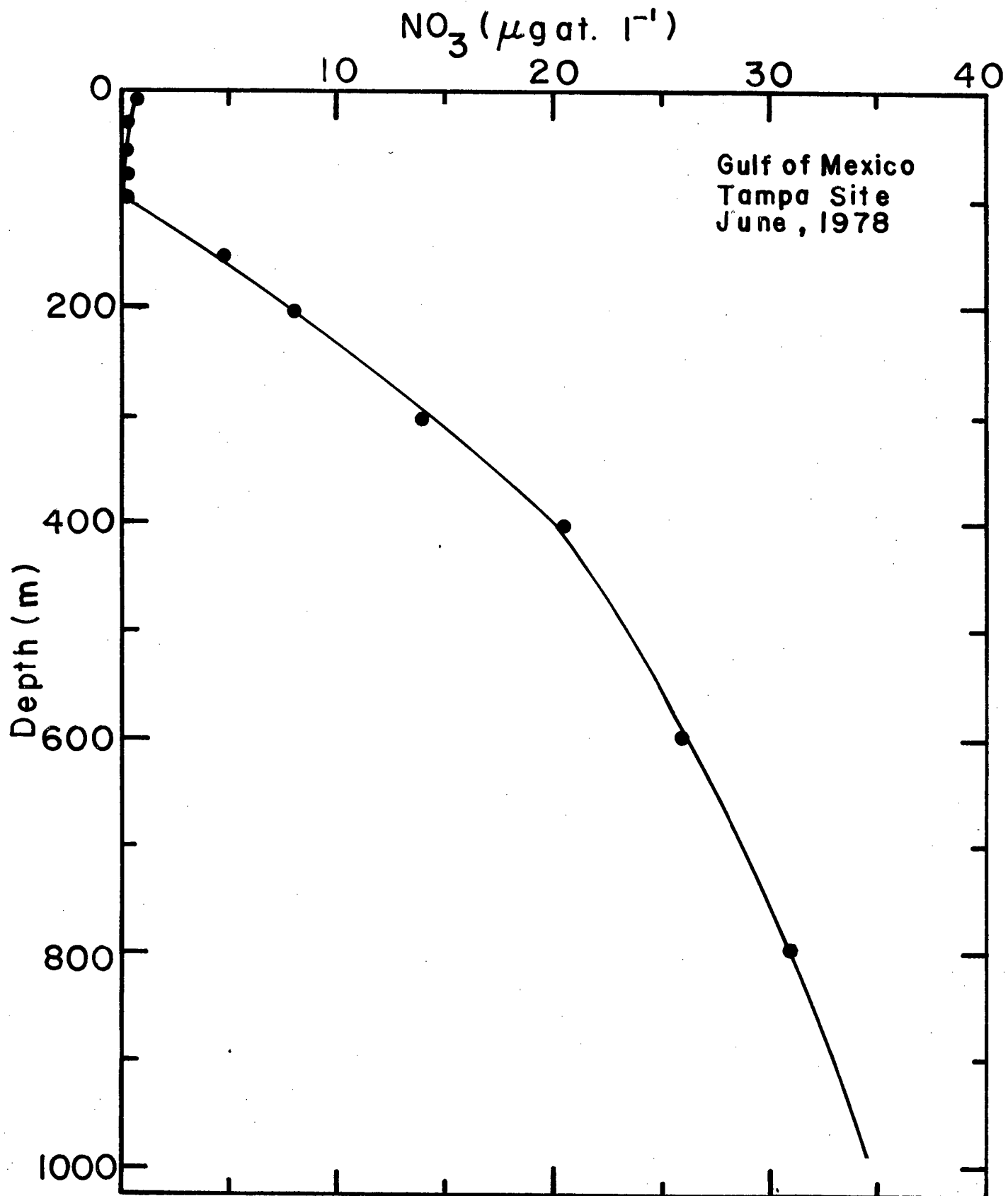
GULF OF MEXICO - TAMPA SITE

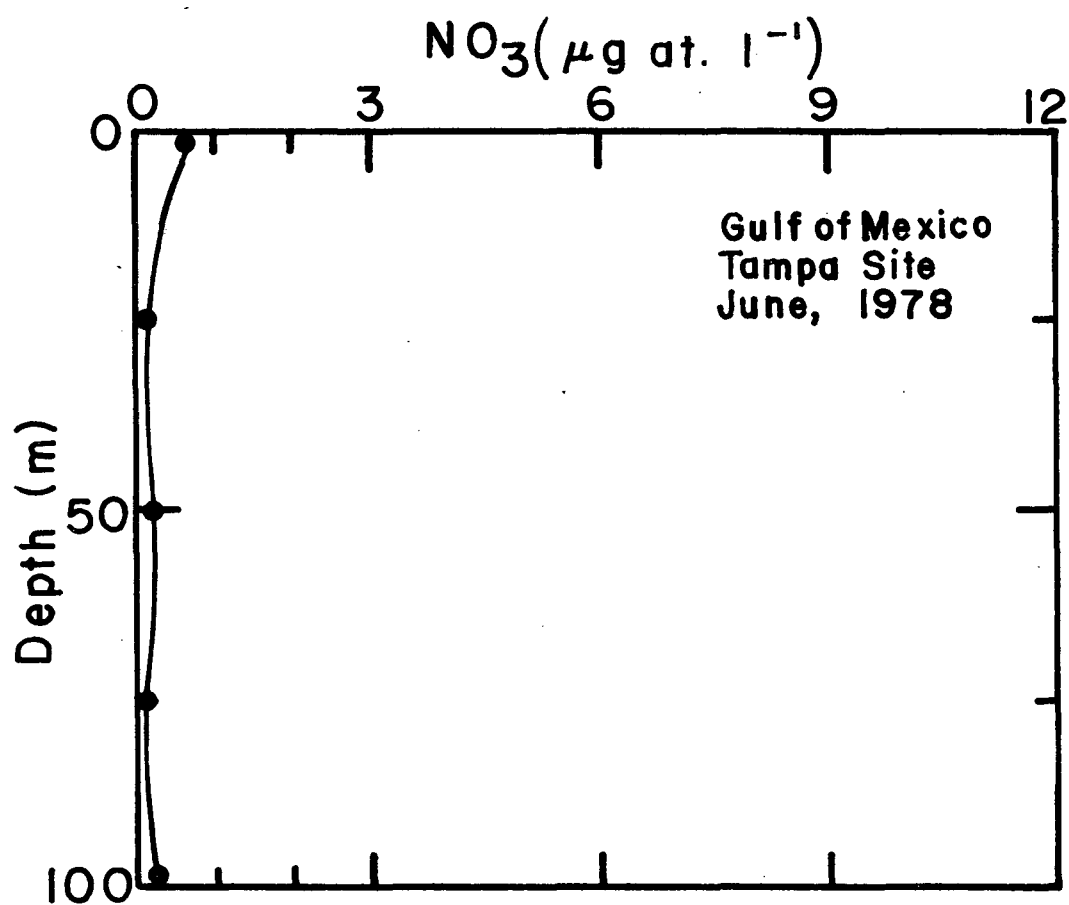
STATION, TIME AND POSITION UNCERTAIN (June, 1978) Depths Estimated

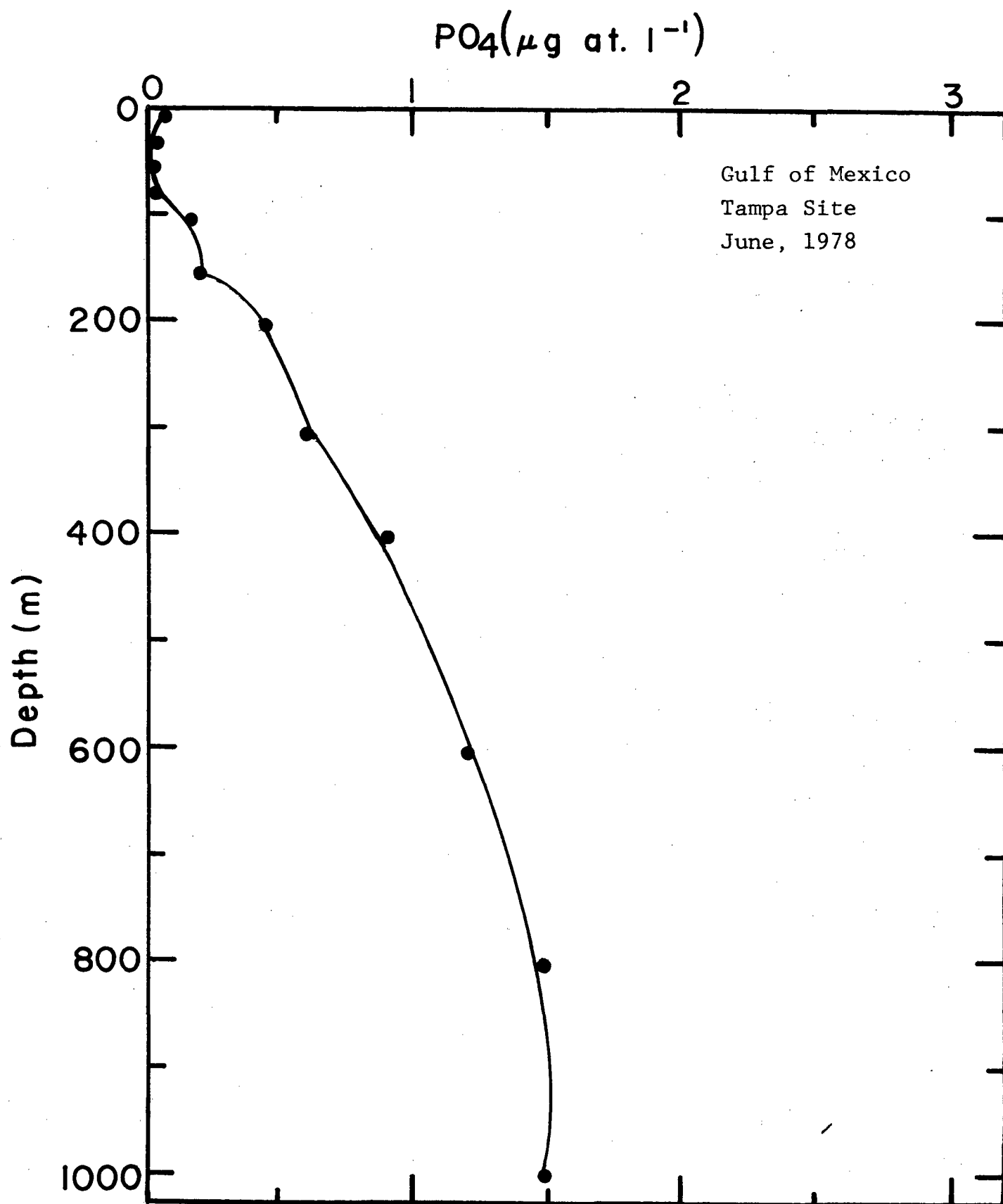
Depth (uncorrected m)	O_2^* (ml ℓ^{-1})	NO_2 ($\mu\text{g at } \ell^{-1}$)	NO_3 ($\mu\text{g at } \ell^{-1}$)	NH_3^* ($\mu\text{g at } \ell^{-1}$)	PO_4 ($\mu\text{g at } \ell^{-1}$)	ΣPO_4^{**} ($\mu\text{g at } \ell^{-1}$)	SiO_3 ($\mu\text{g at } \ell^{-1}$)
0	-	0.17	0.98	-	0.05	-	0.10
25	-	0.10	0.10	-	0	-	0
50	-	0.05	0.27	-	0	-	0
75	-	0	0.10	-	0	-	0.50
100	-	0.03	0.19	-	0.15	-	0
150	-	0.05	5.0	-	0.20	-	1.0
200	-	0.06	7.9	-	0.45	-	2.5
300	-	0.07	14	-	0.60	-	3.5
400	-	0.08	20	-	0.90	-	6.5
600	-	0.05	26	-	1.2	-	9.5
800	-	0.06	31	-	1.5	-	15
1000	-	0.12	35	-	1.5	-	16

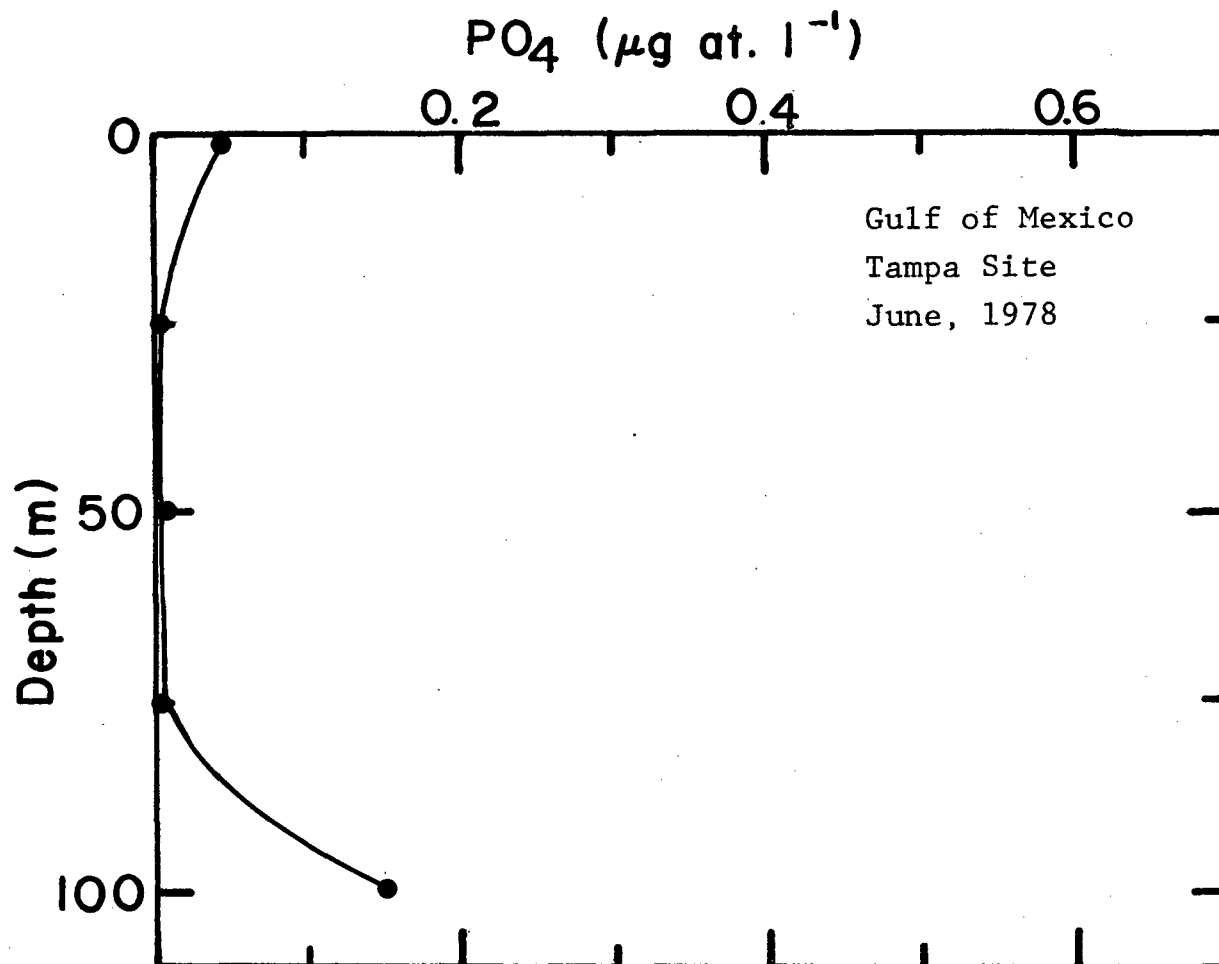
* Not reported due to improper sample preservation

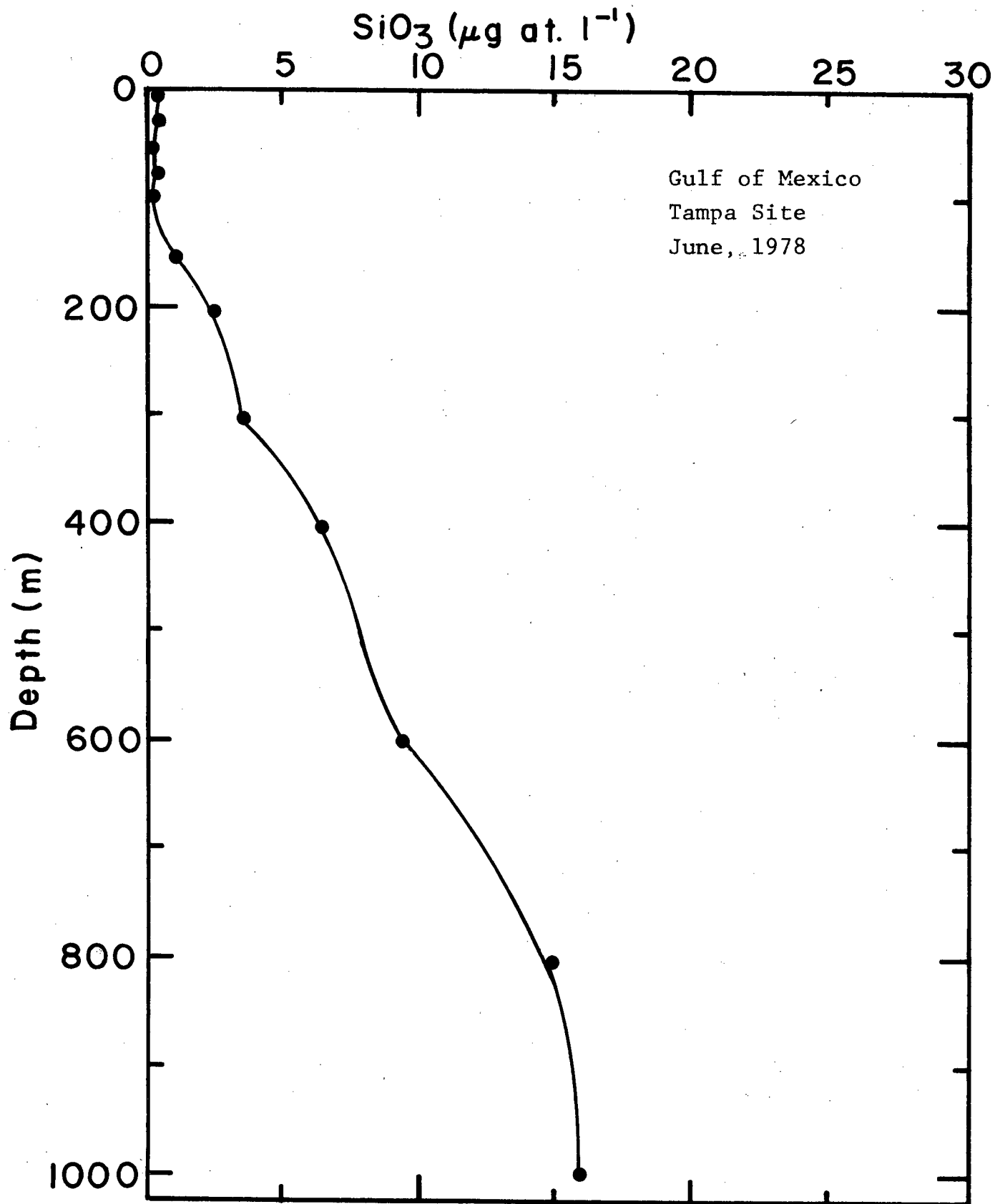
** Not determined





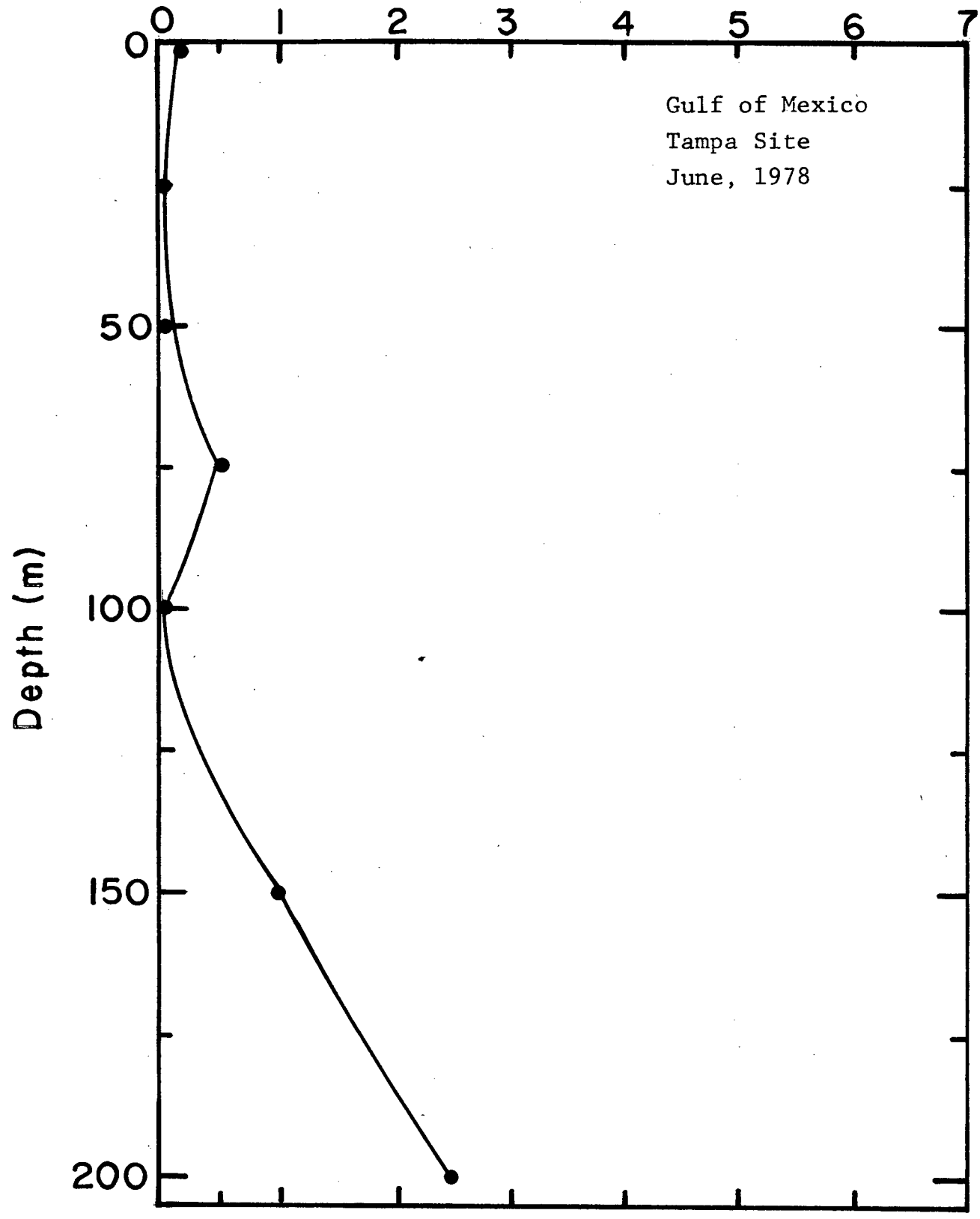






$\text{SiO}_3 (\mu\text{g at. l}^{-1})$

Gulf of Mexico
Tampa Site
June, 1978



GULF OF MEXICO - TAMPA SITE

STATION 8

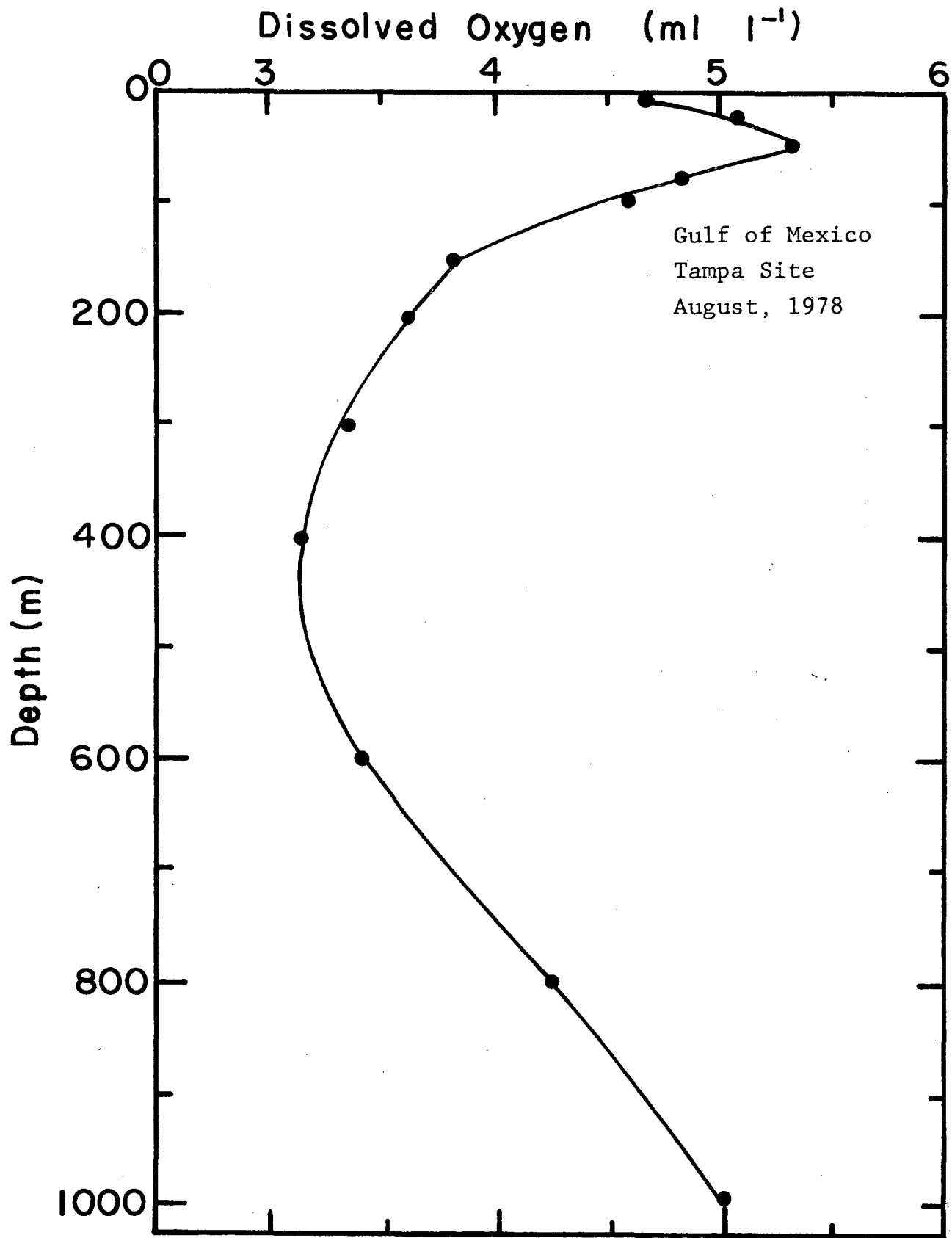
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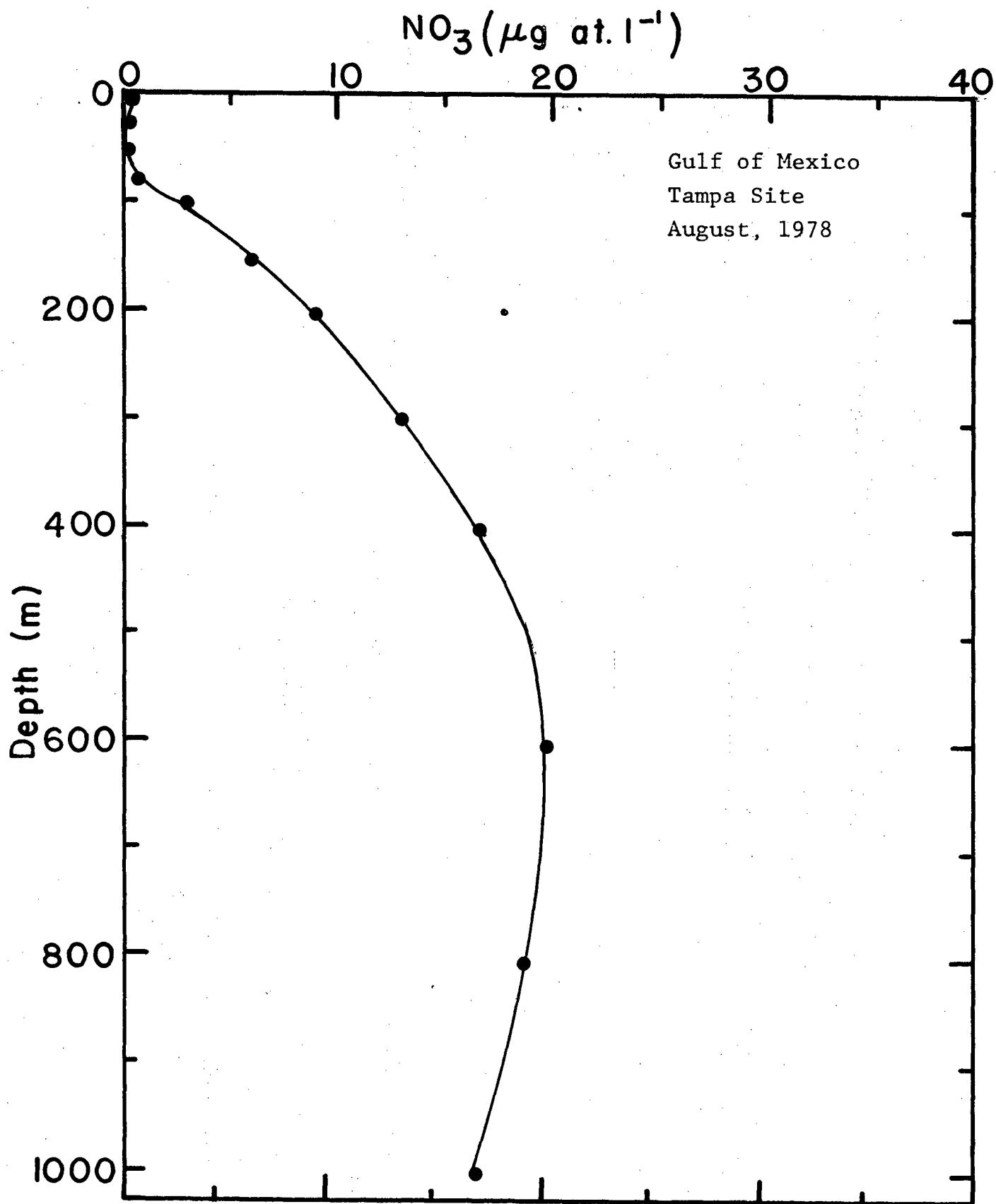
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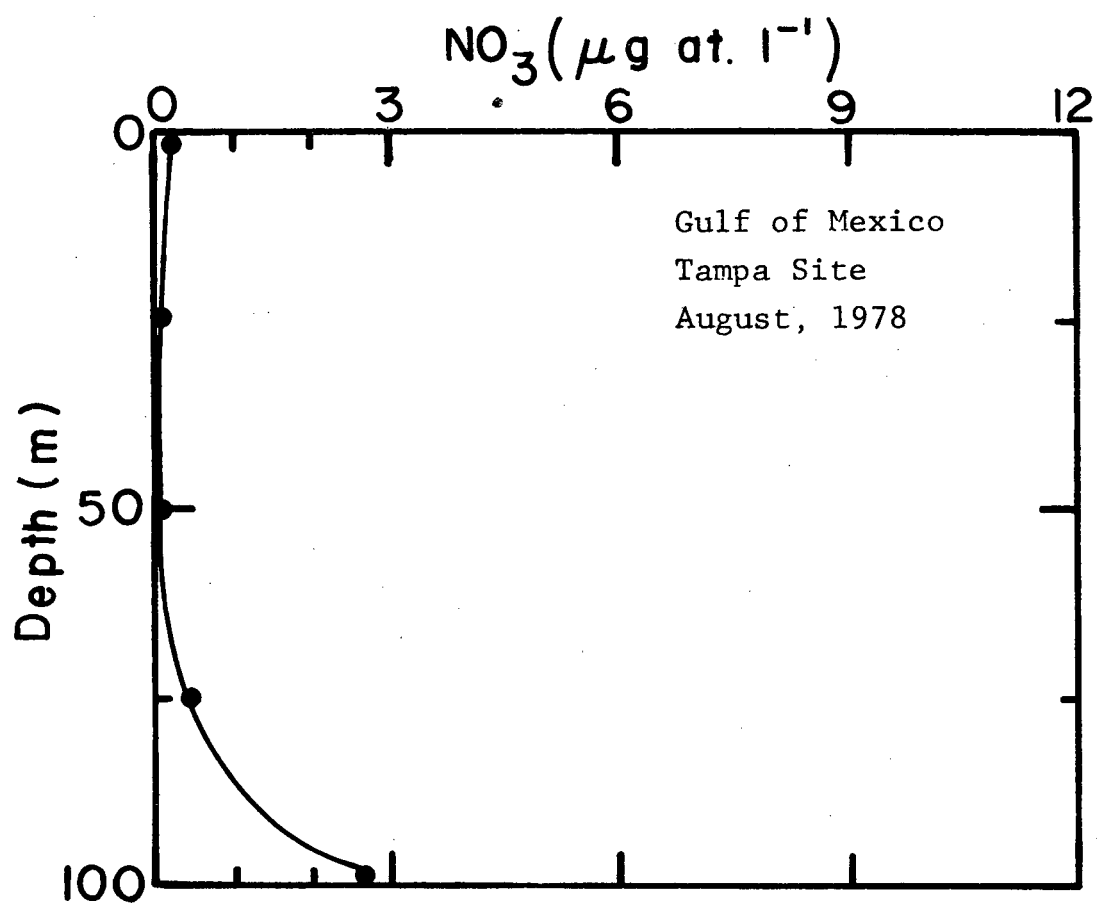
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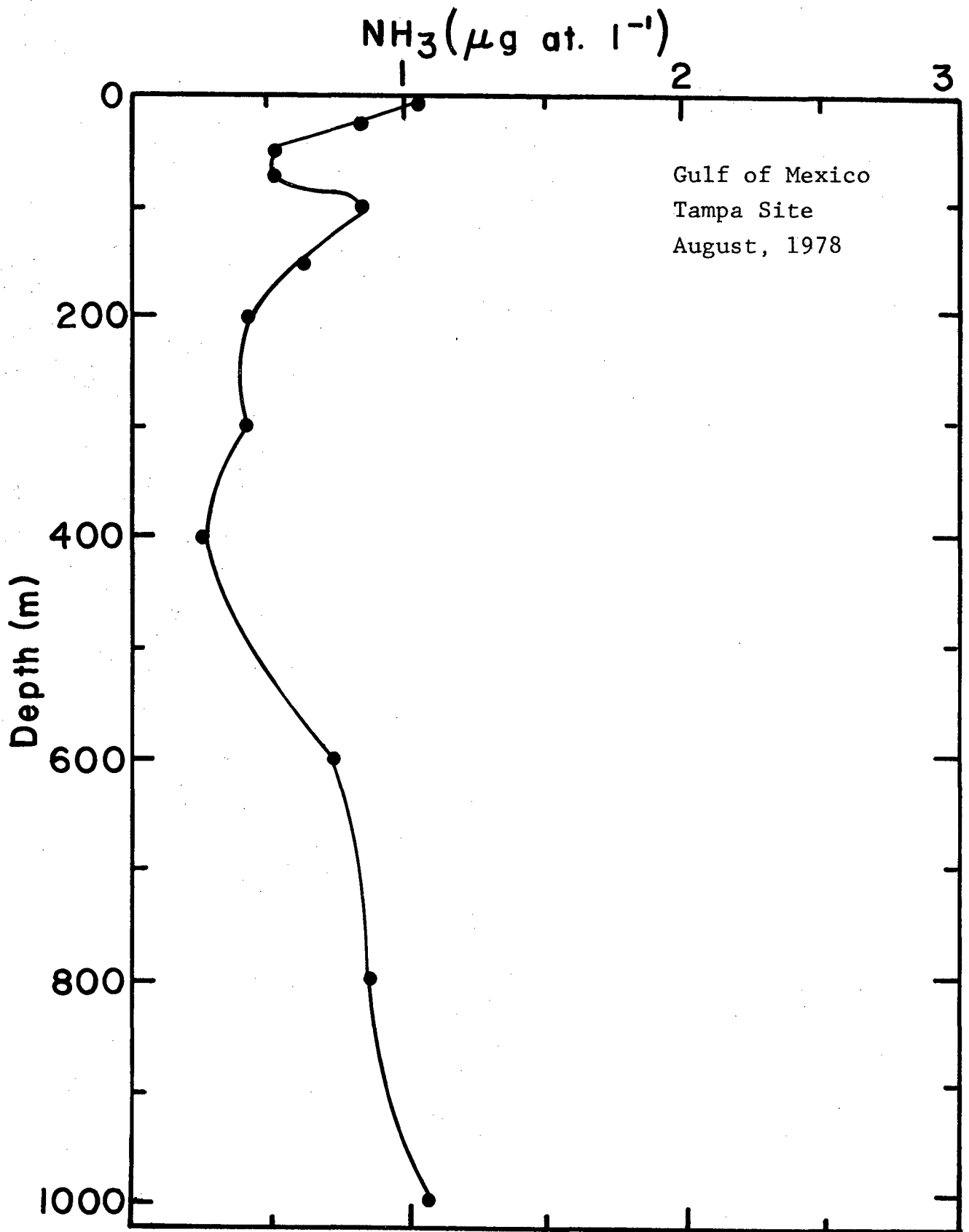
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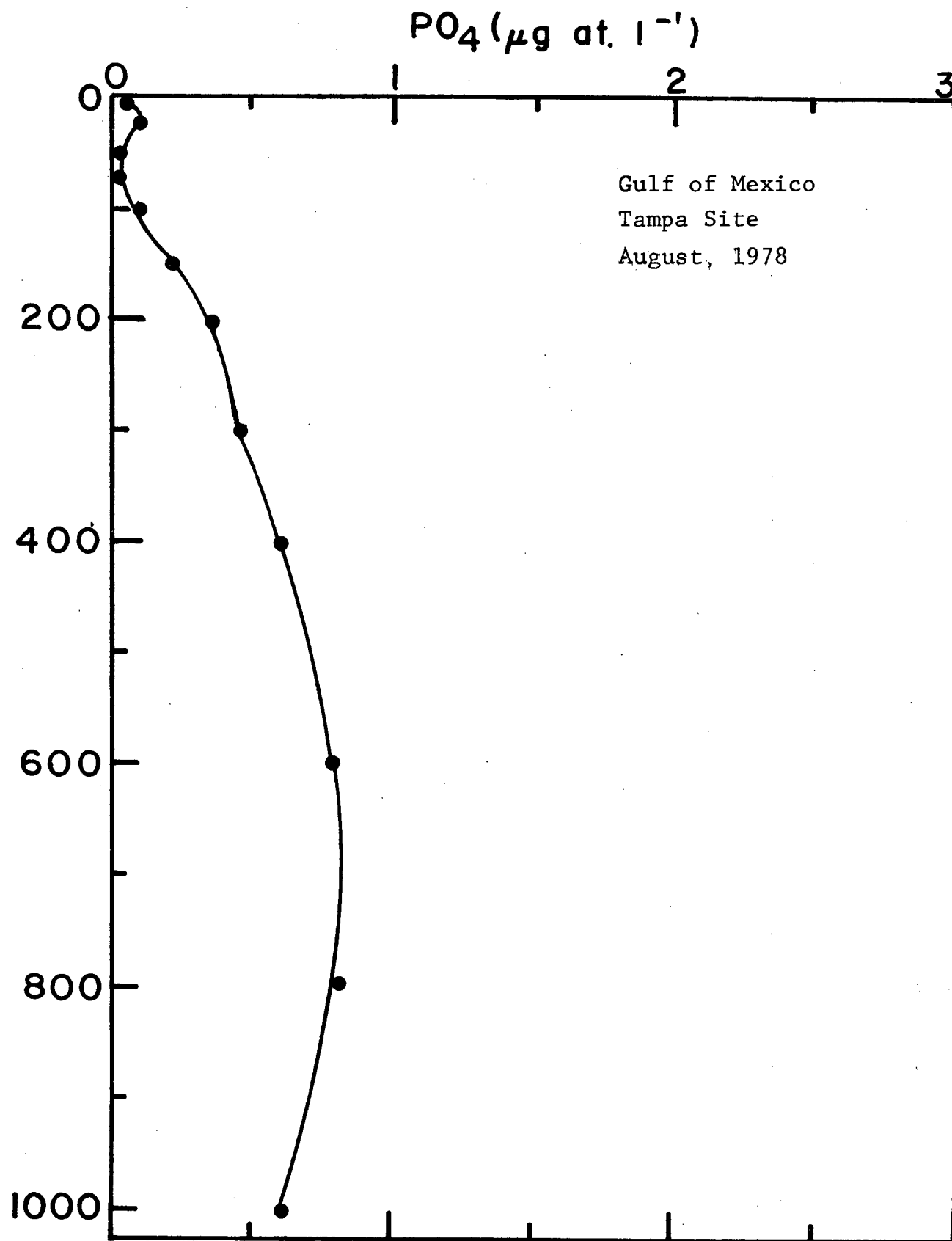
Depth (uncorrected m)	O_2 (ml ℓ^{-1})	NO_2 (μg at ℓ^{-1})	NO_3 (μg at ℓ^{-1})	NH_3 (μg at ℓ^{-1})	PO_4 (μg at ℓ^{-1})	ΣPO_4 (μg at ℓ^{-1})	SiO_3 (μg at ℓ^{-1})
0	4.7	0	0.10	1.1	0.05	0.11	0.10
25	5.1	0	0	0.89	0.10	0.33	0.10
50	5.4	0	0	0.57	0	0.42	0.05
75	4.9	0	0.50	0.57	0	0.72	0.08
100	4.6	0	2.8	0.89	0.10	1.1	0.10
150	3.9	0	6.0	0.64	0.20	1.3	1.5
200	3.6	0	9.0	0.43	0.35	1.4	3.0
300	3.4	0	13	0.43	0.45	1.6	6.5
400	3.2	0	17	0.28	0.60	1.8	10
600	3.4	0	20	0.78	0.75	2.0	17
800	4.2	0	19	0.89	0.80	1.9	21
1000	5.0	0	17	1.1	0.60	1.8	21

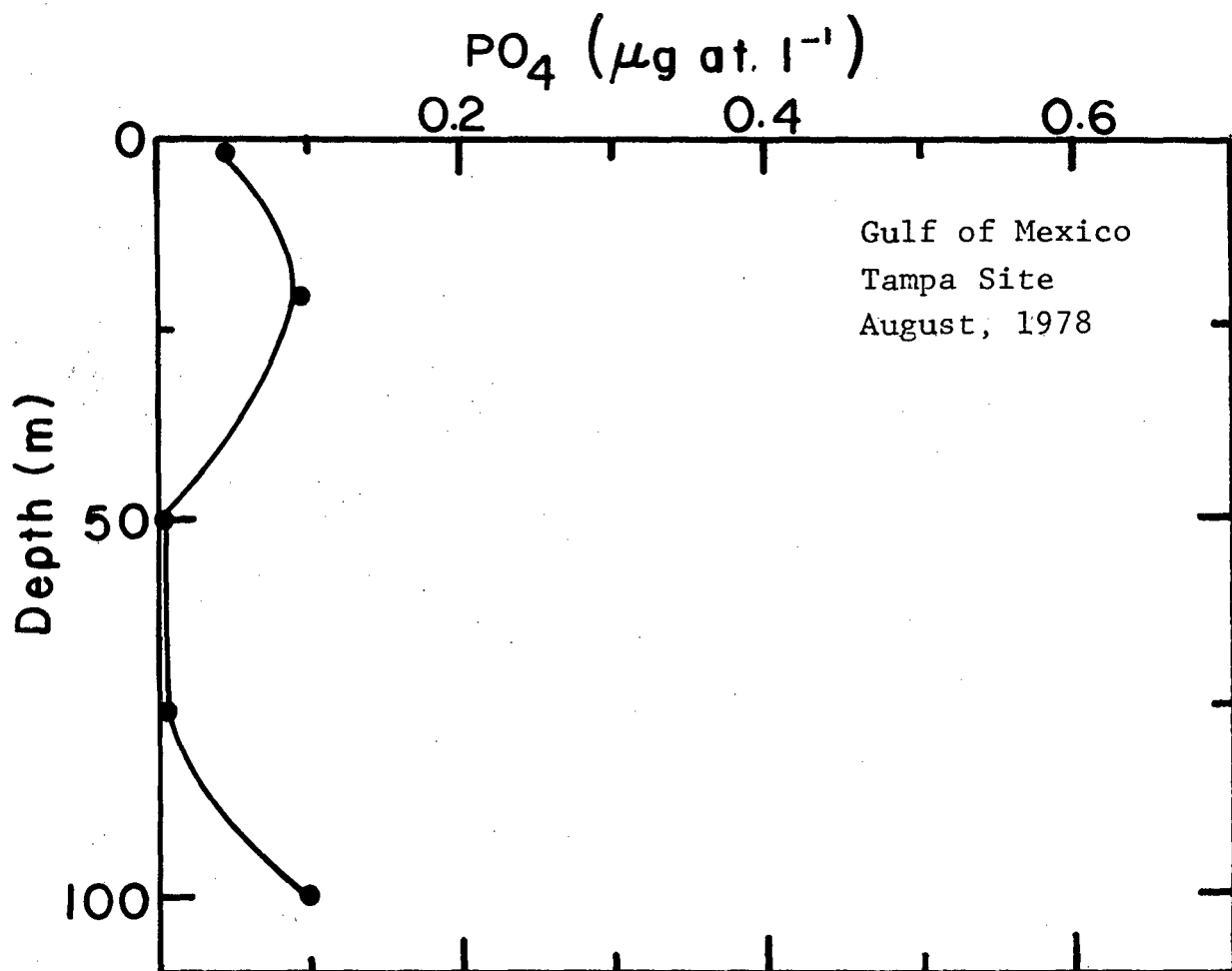


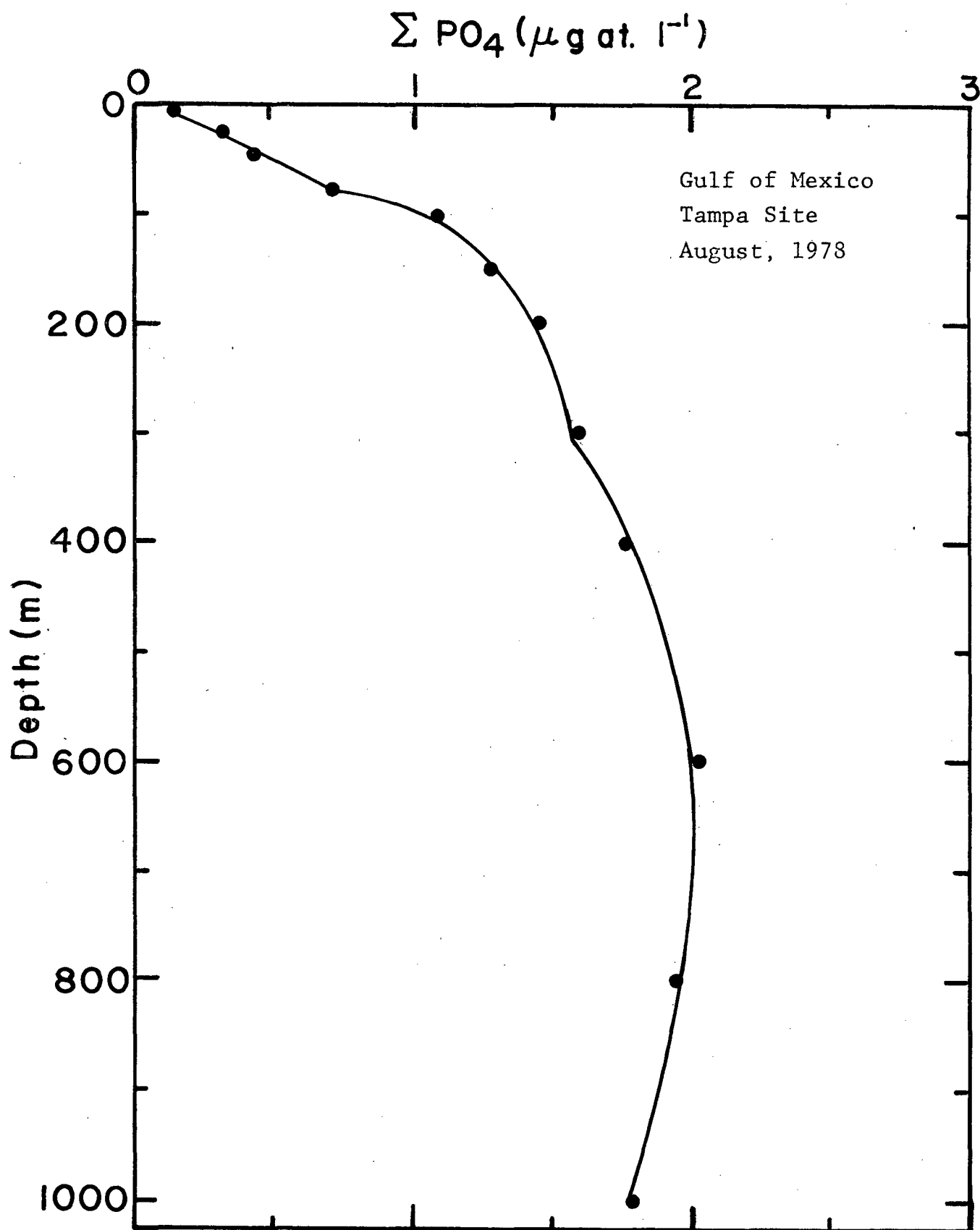


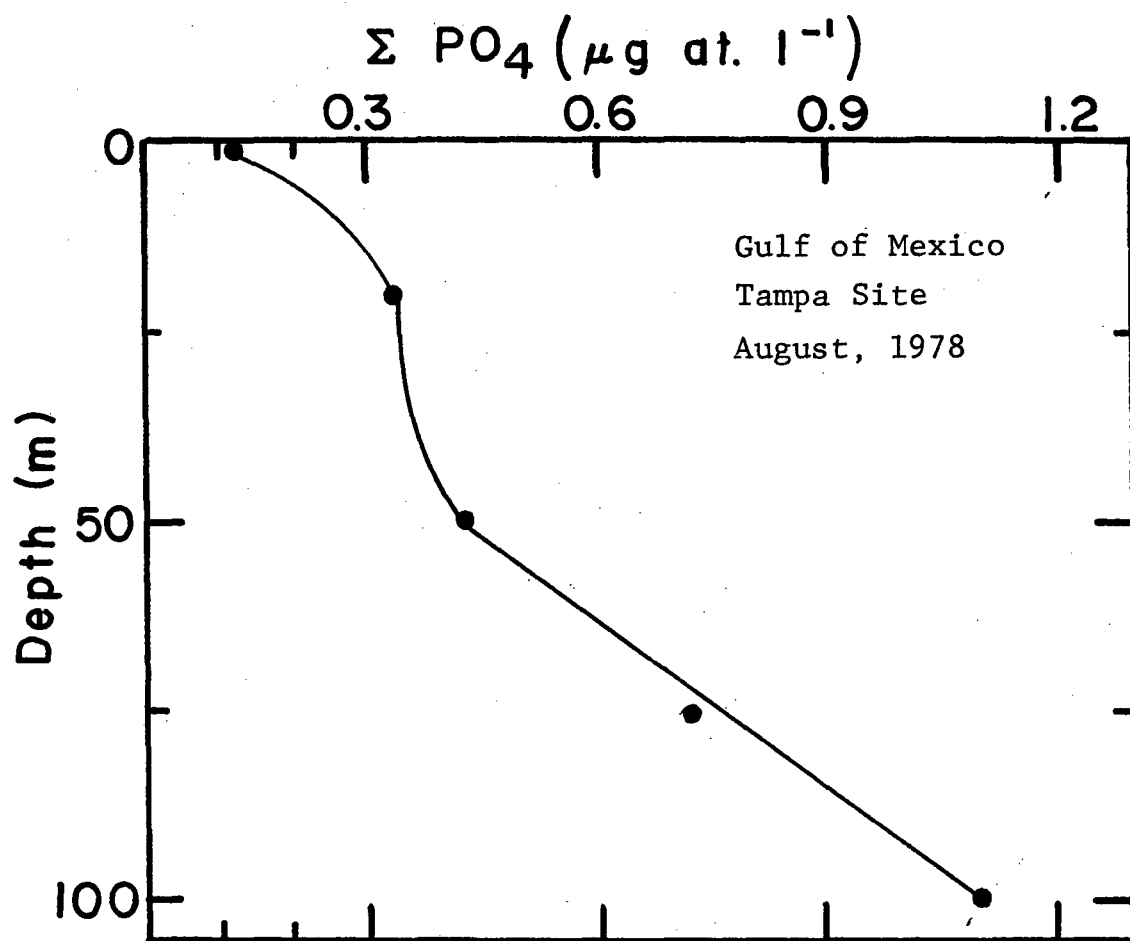


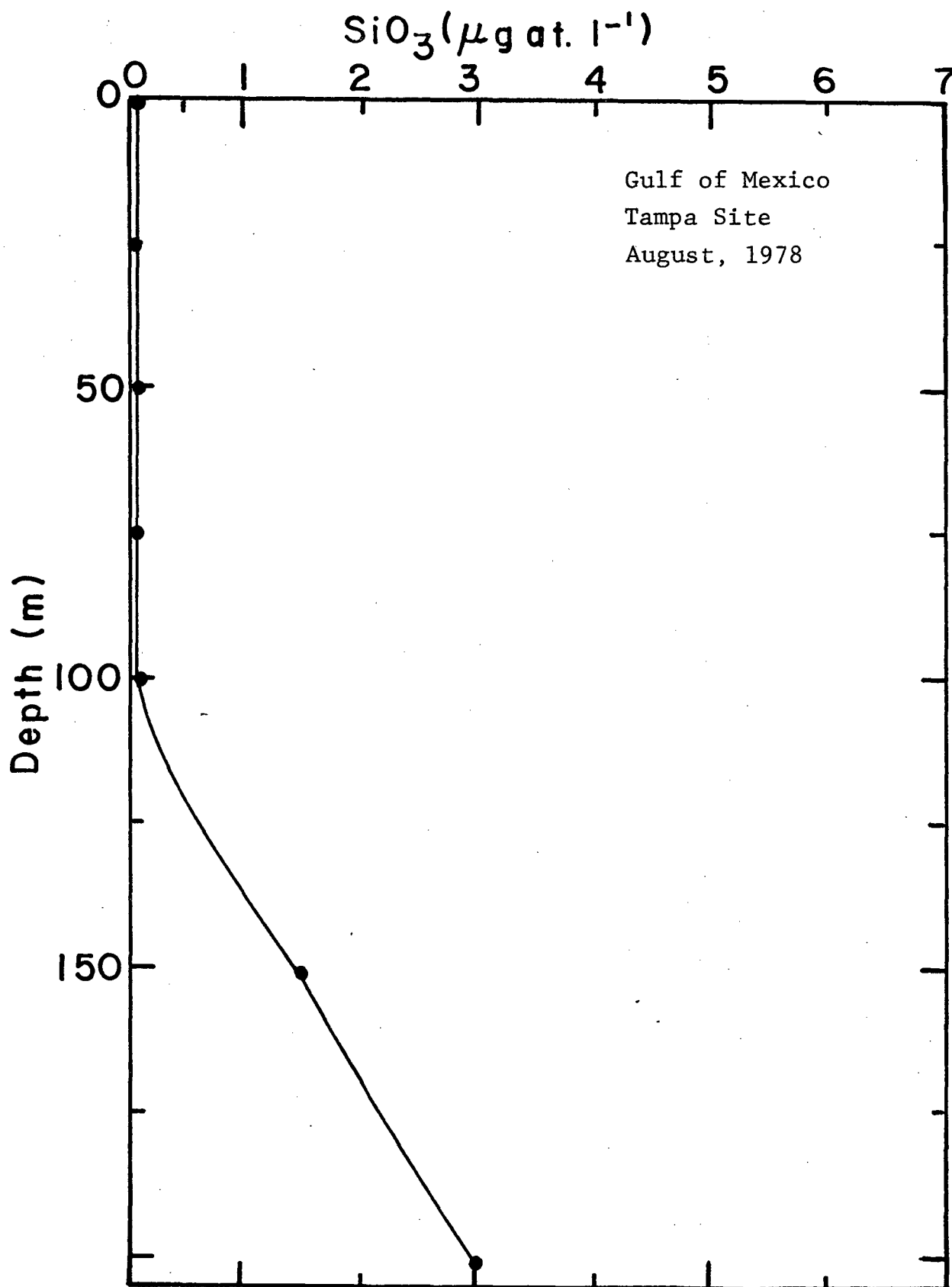


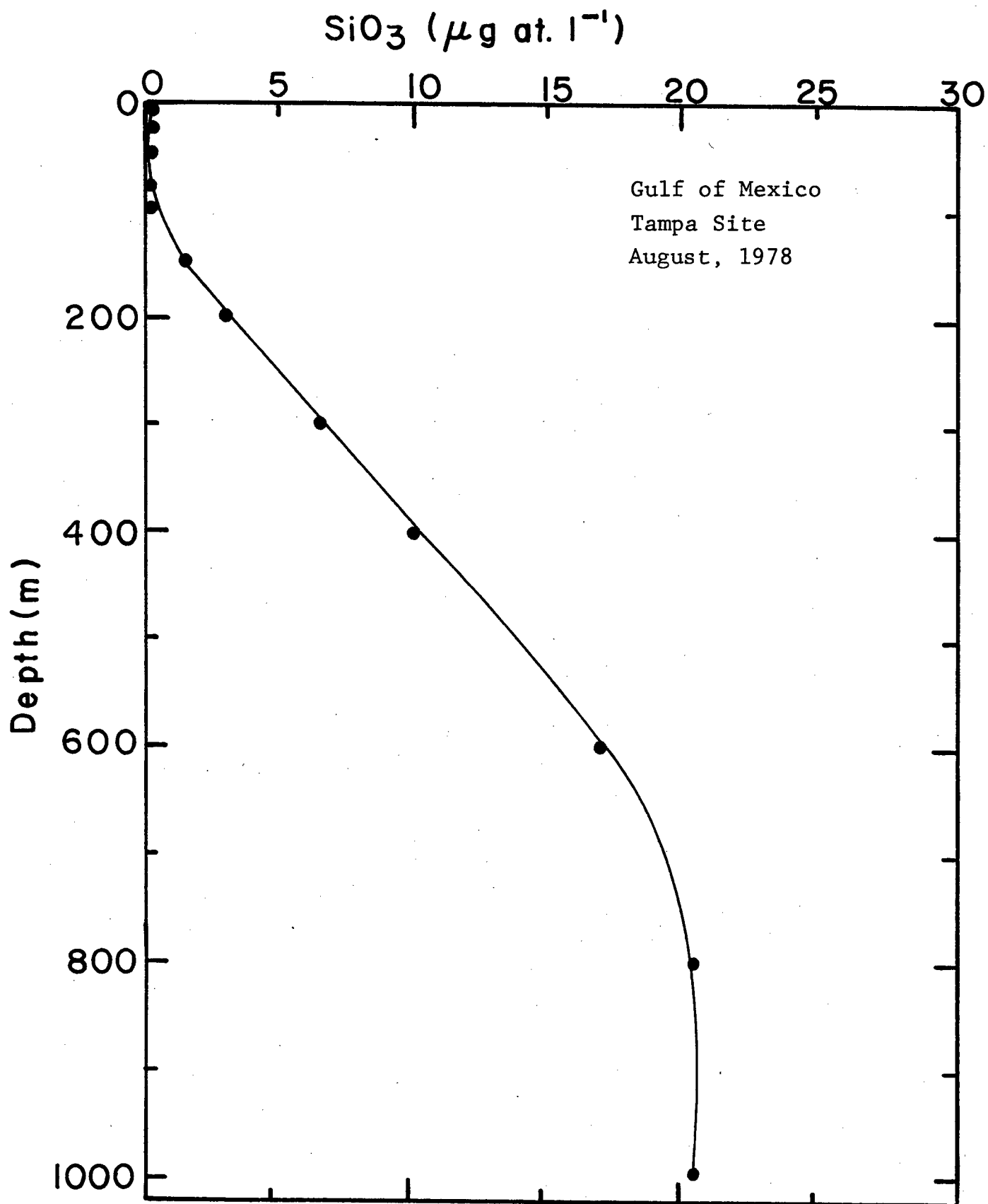












GULF OF MEXICO - TAMPA SITE

STATION 5

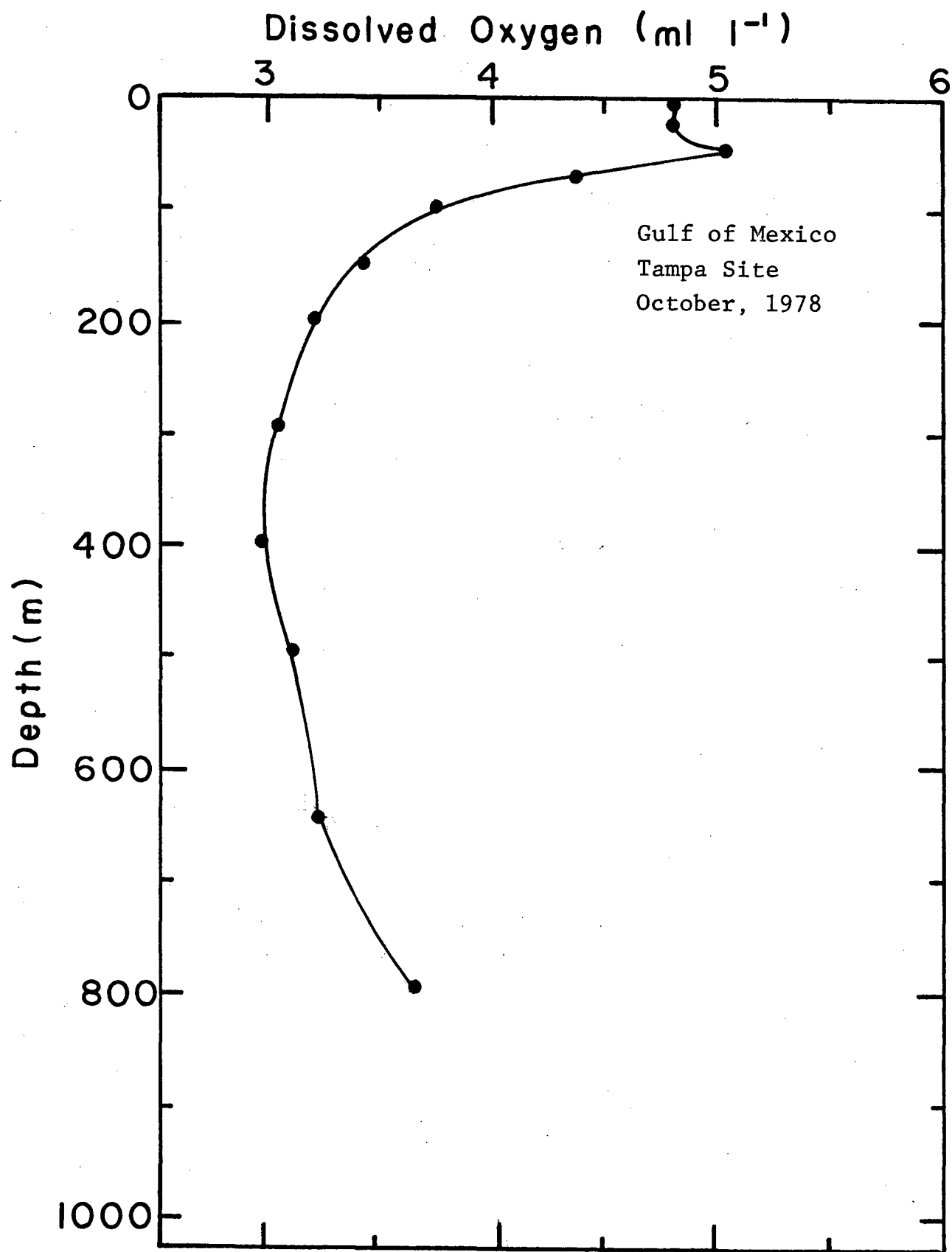
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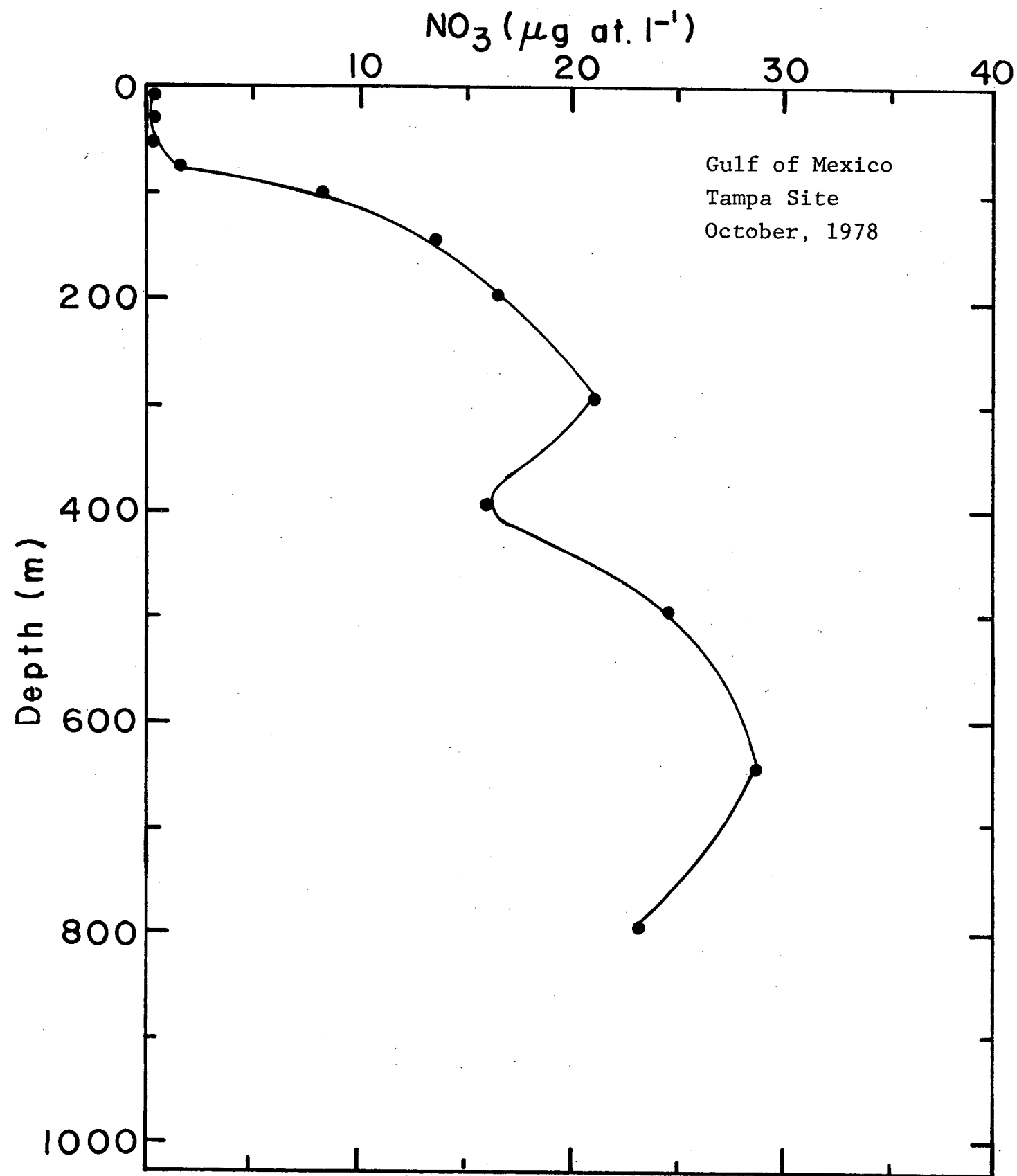
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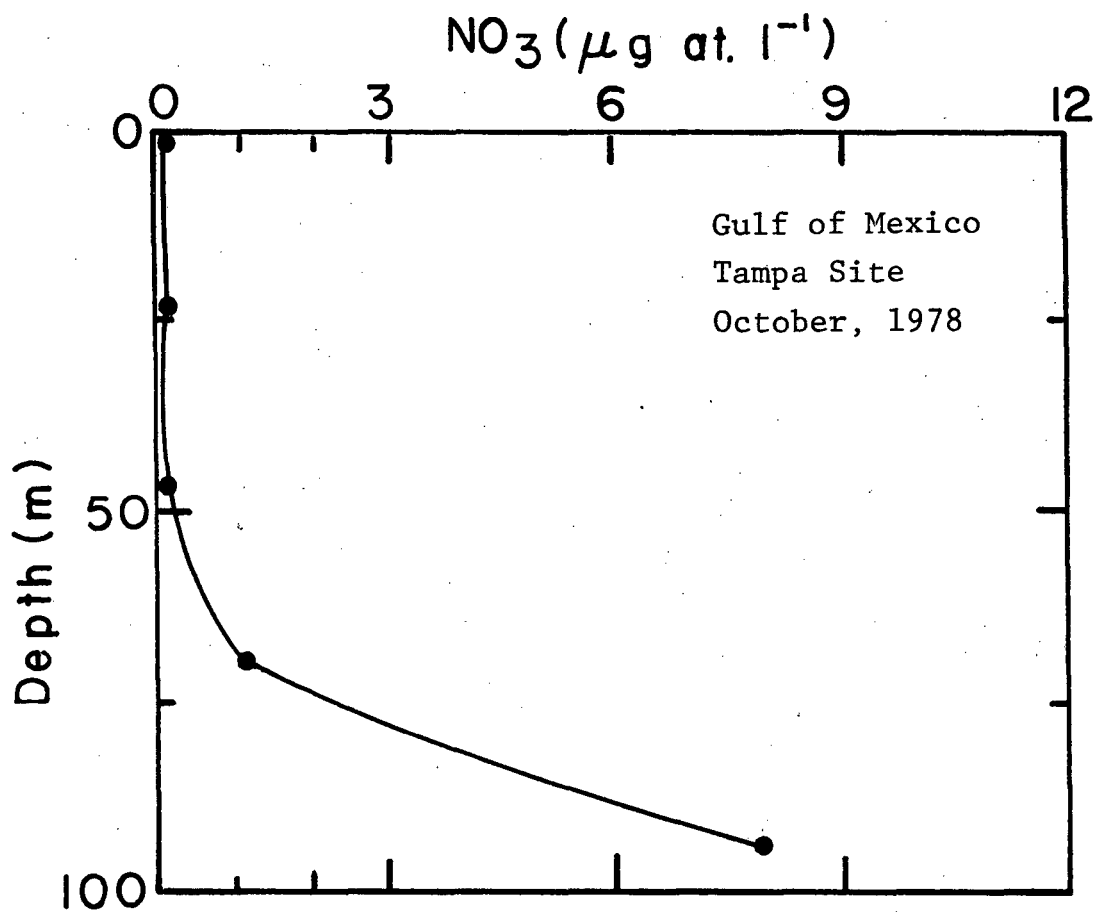
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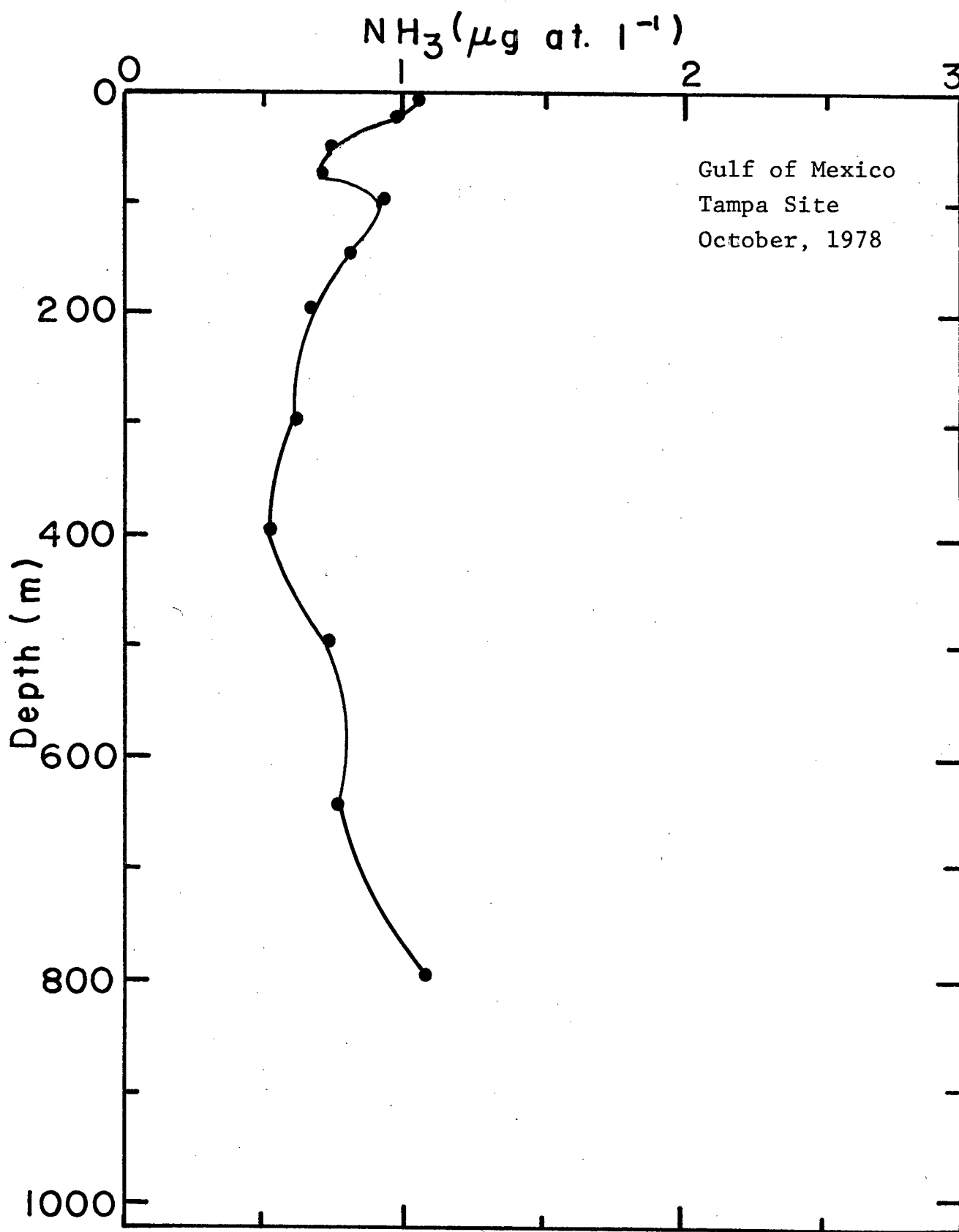
85° 35'W

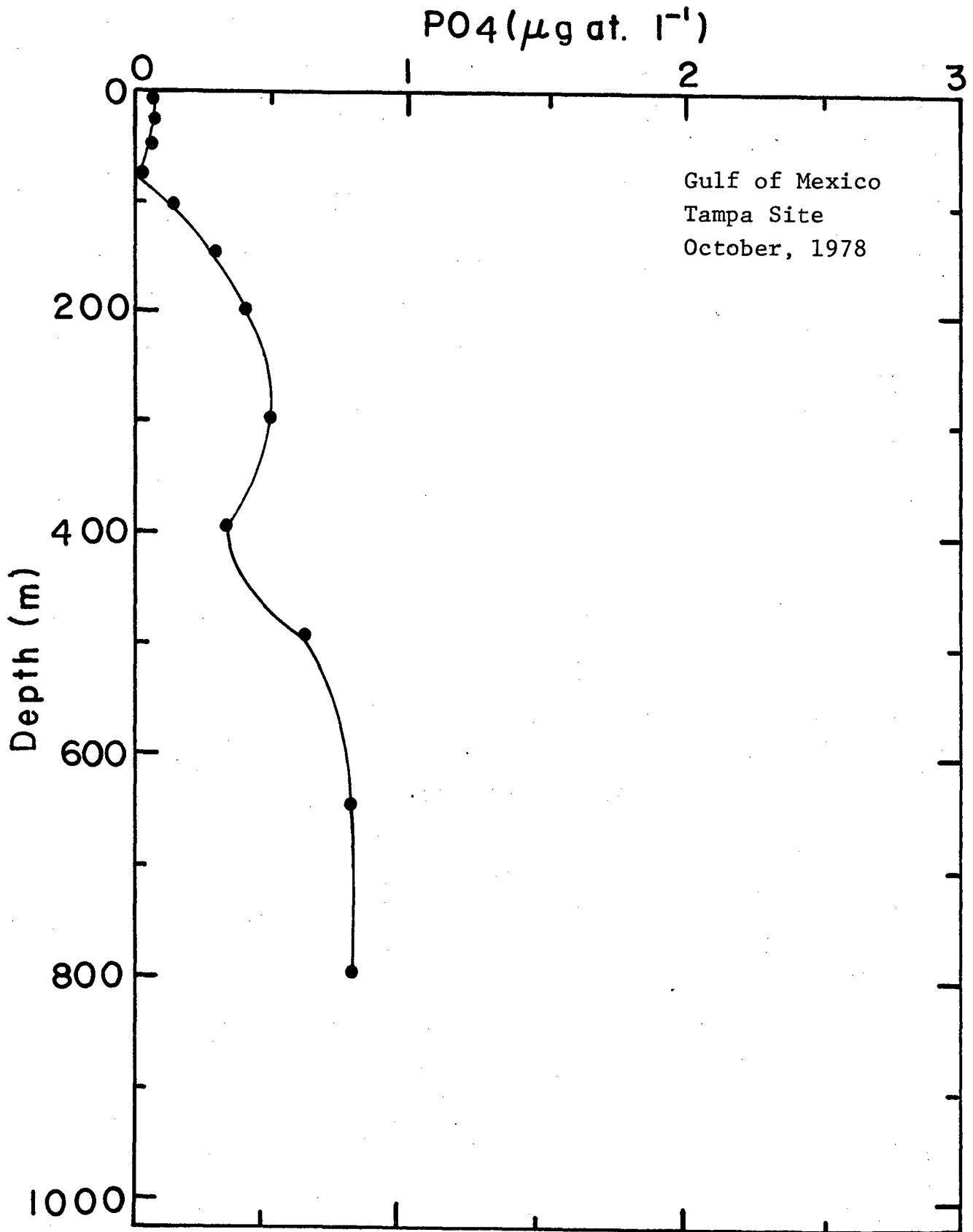
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0	4.8	0.05	0.05	1.1	0.07	0.09	1.0
23	4.8	0.05	0.05	0.98	0.08	0.18	1.0
46	5.1	0.05	0.05	0.73	0.05	0.63	0.50
70	4.3	0.05	1.2	0.70	0	0.72	0
94	3.7	0	8.0	0.92	0.15	0.83	2.0
141	3.5	0	13	0.81	0.30	0.94	4.0
190	3.2	0	17	0.67	0.40	1.1	5.5
287	3.1	0	21	0.62	0.50	1.2	8.0
386	3.0	0.05	16	0.53	0.35	1.4	7.0
485	3.1	0.10	24	0.73	0.65	1.7	13
634	3.2	0.05	29	0.78	0.80	1.5	19
784	3.7	0.10	23	1.1	0.80	1.5	17

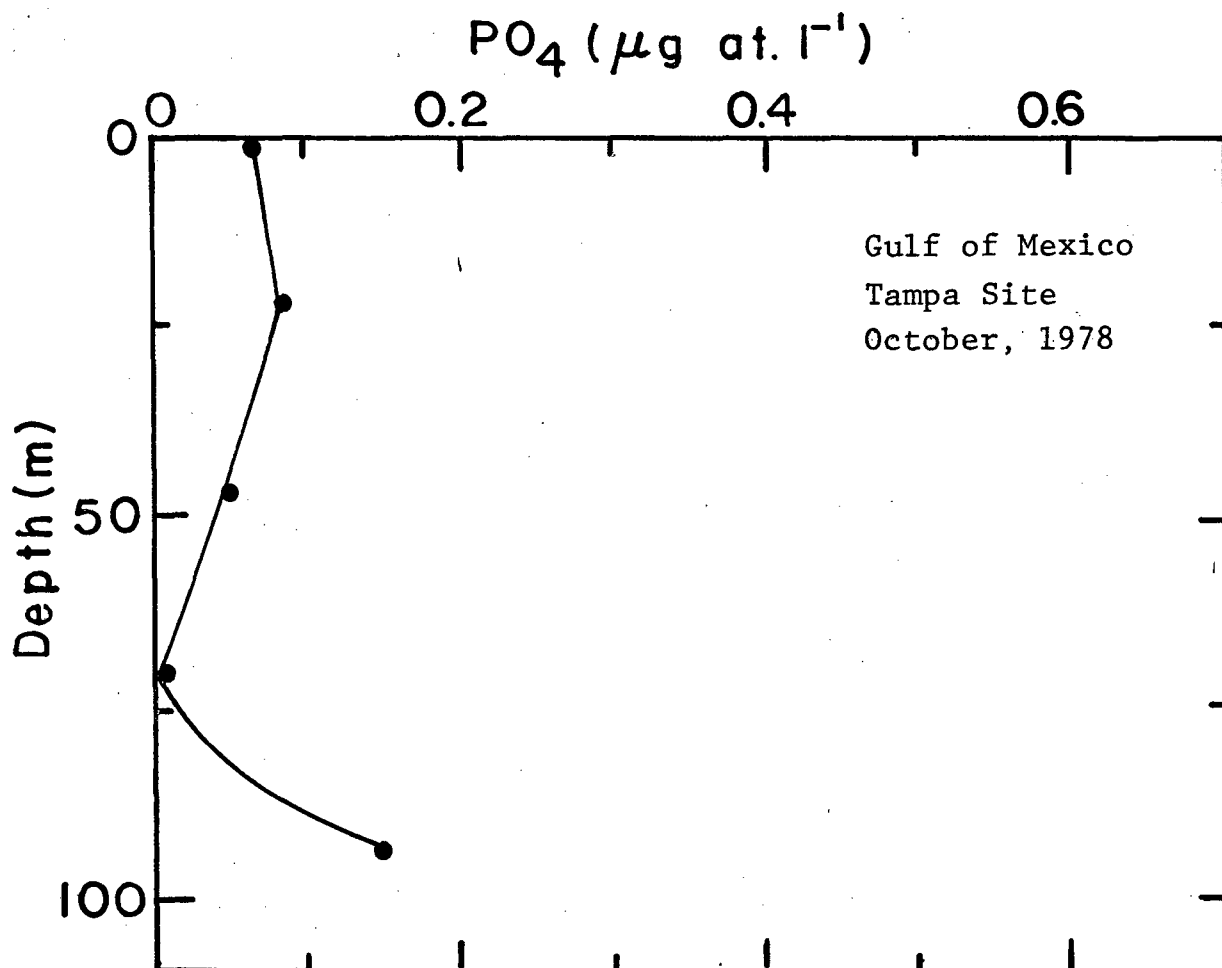


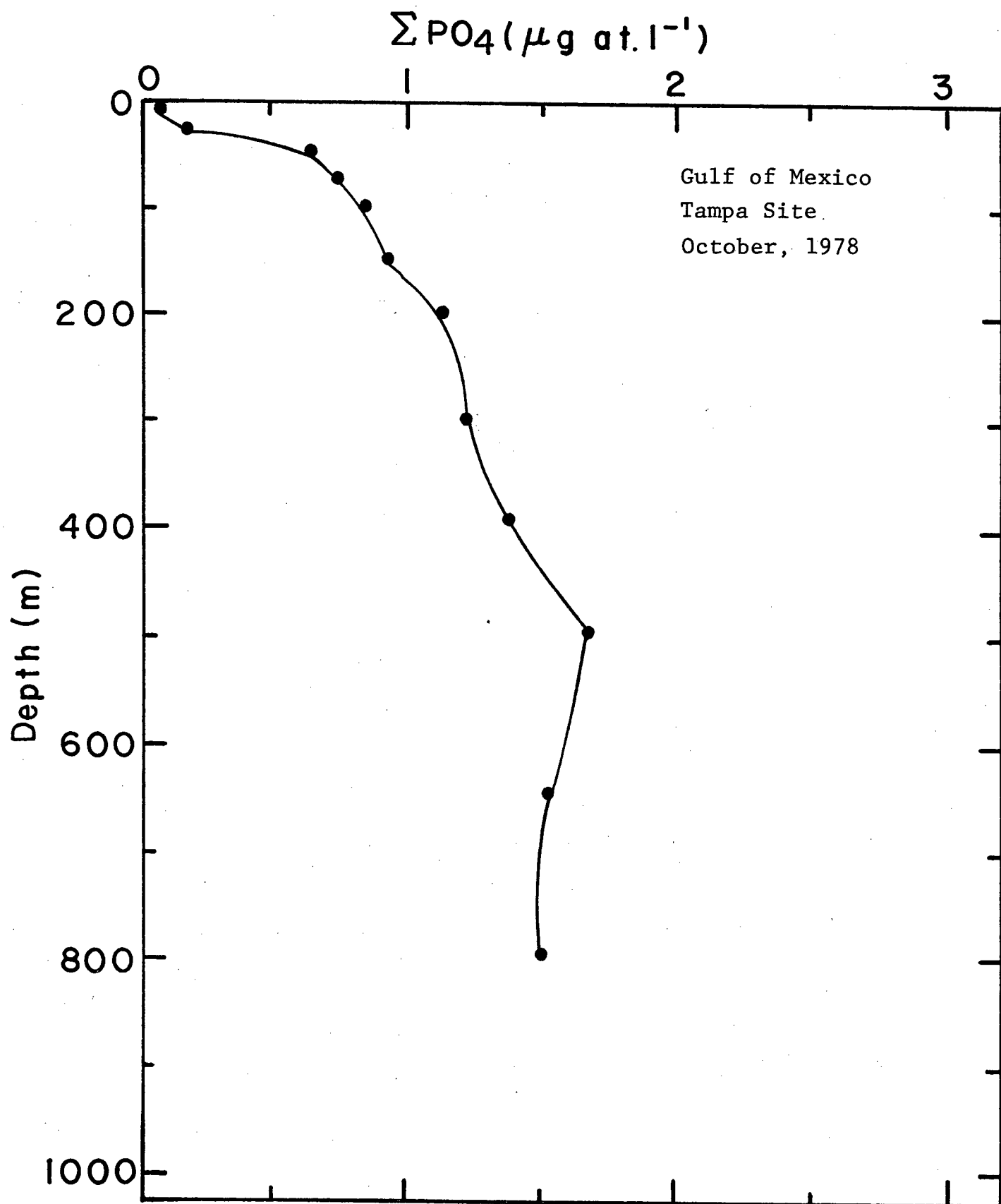


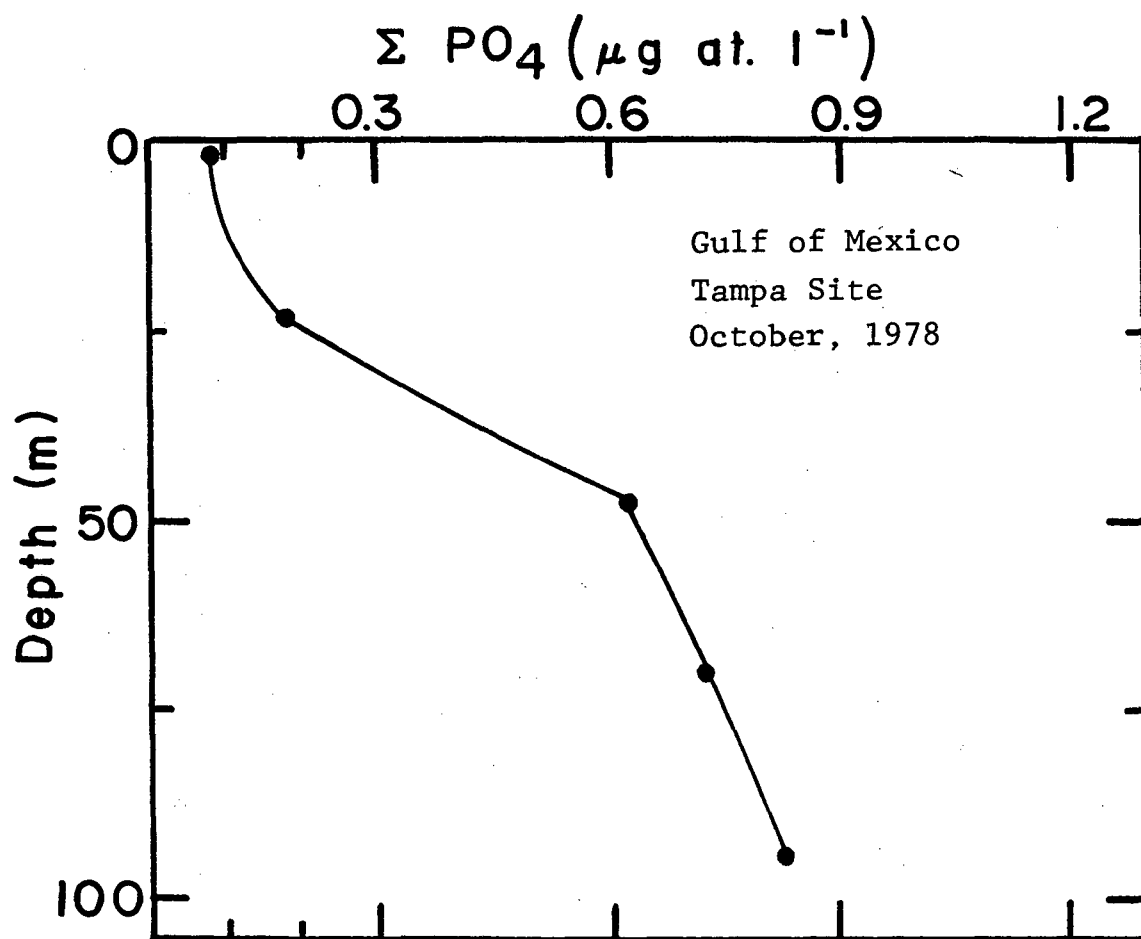


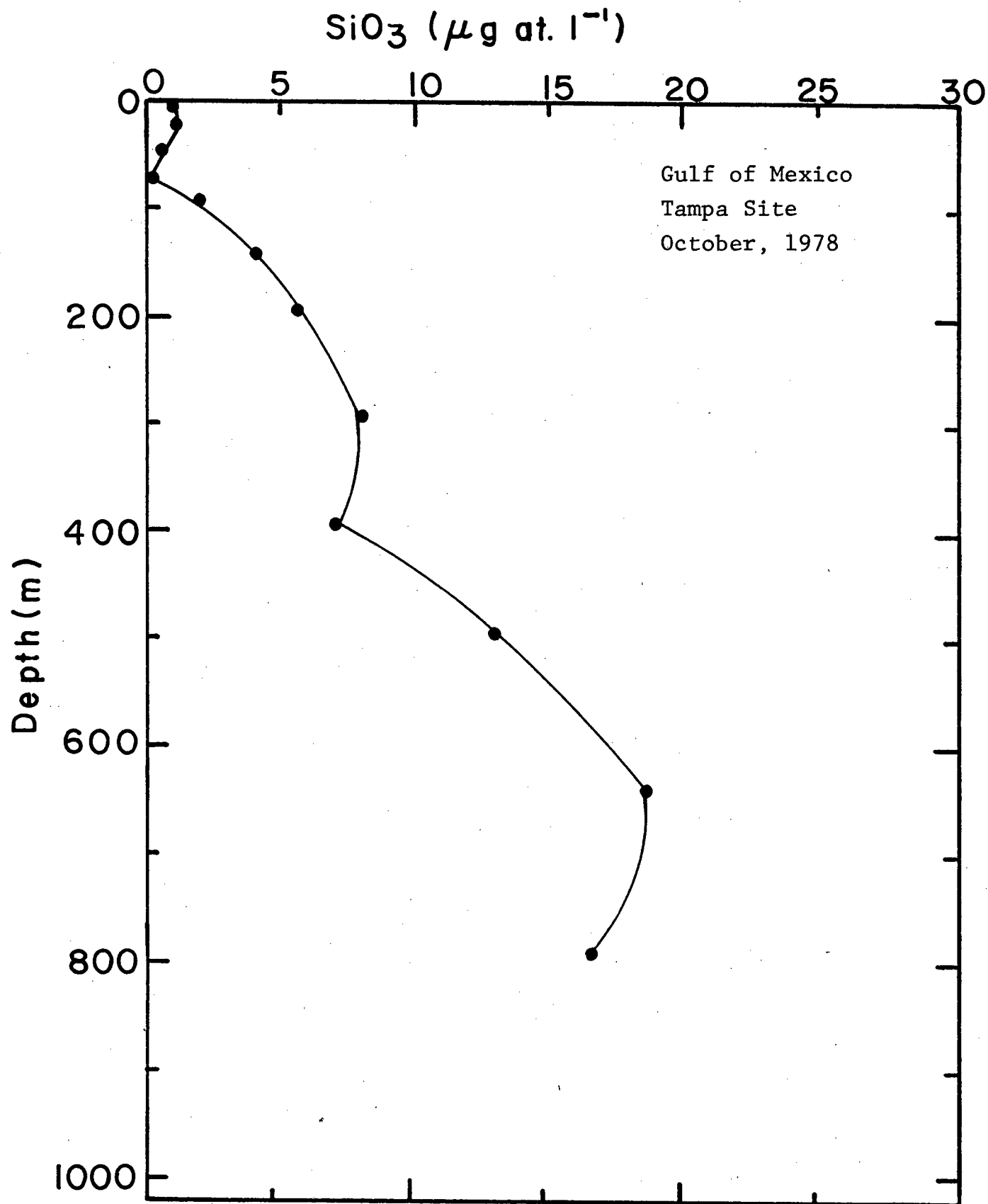


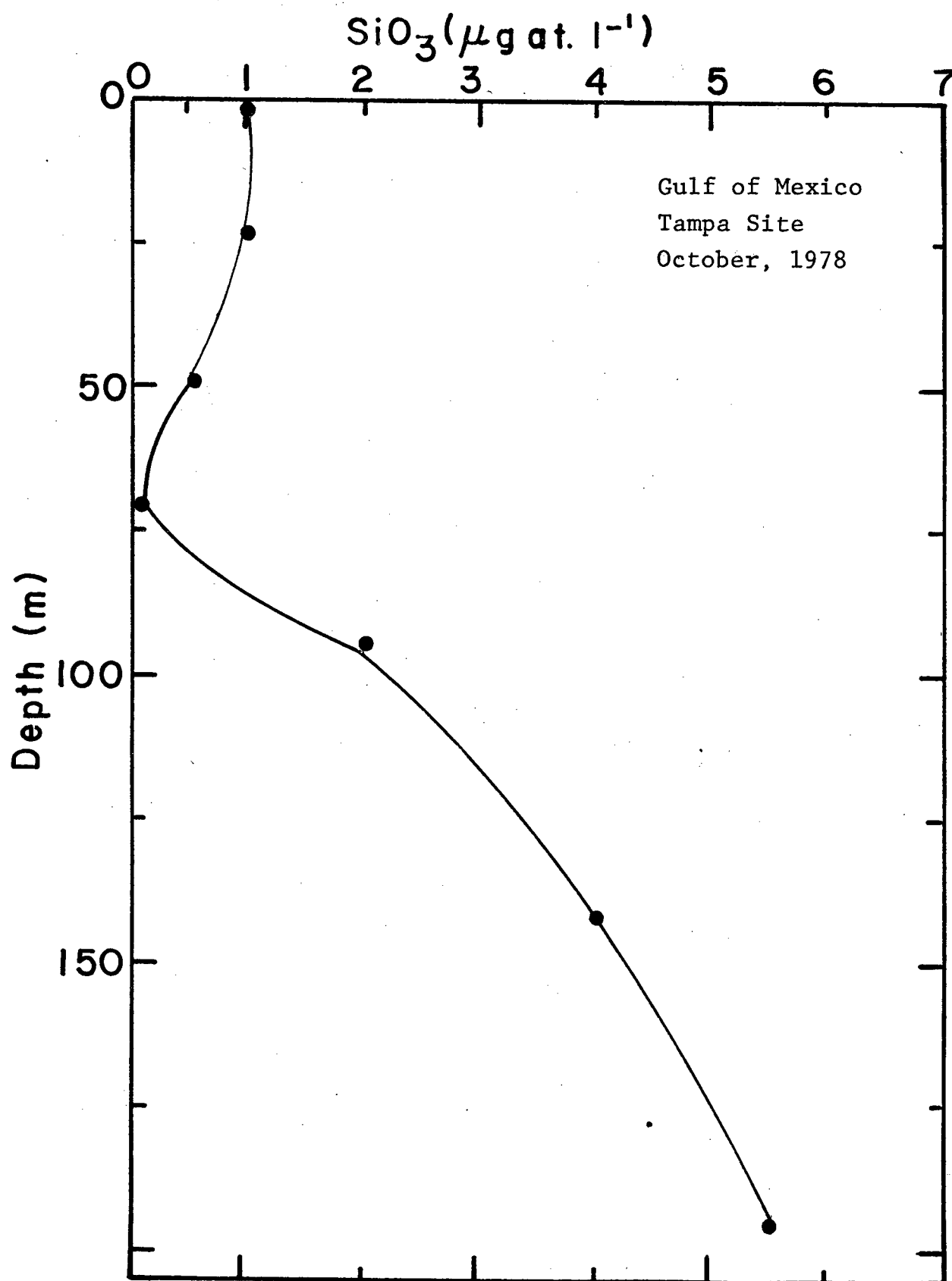








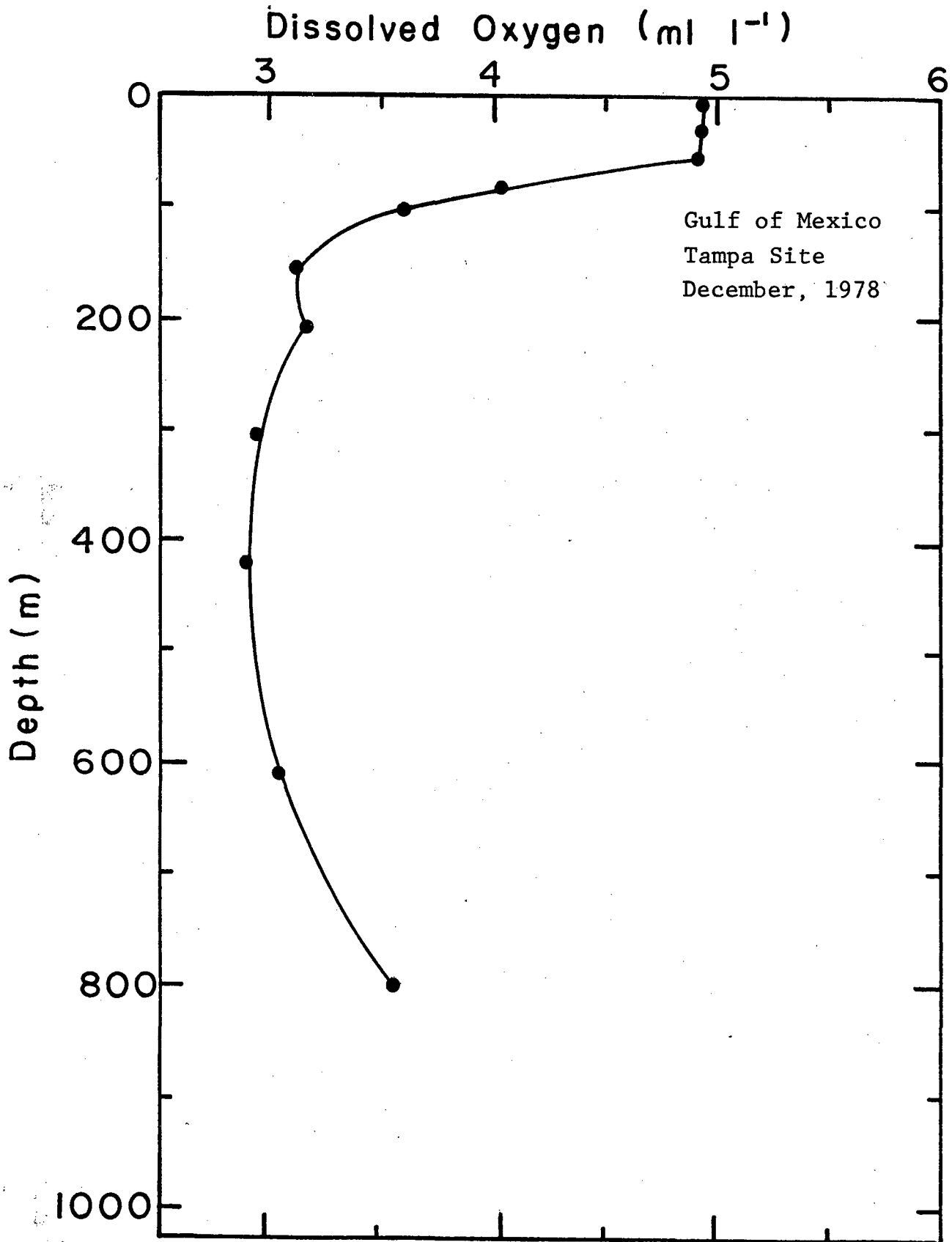


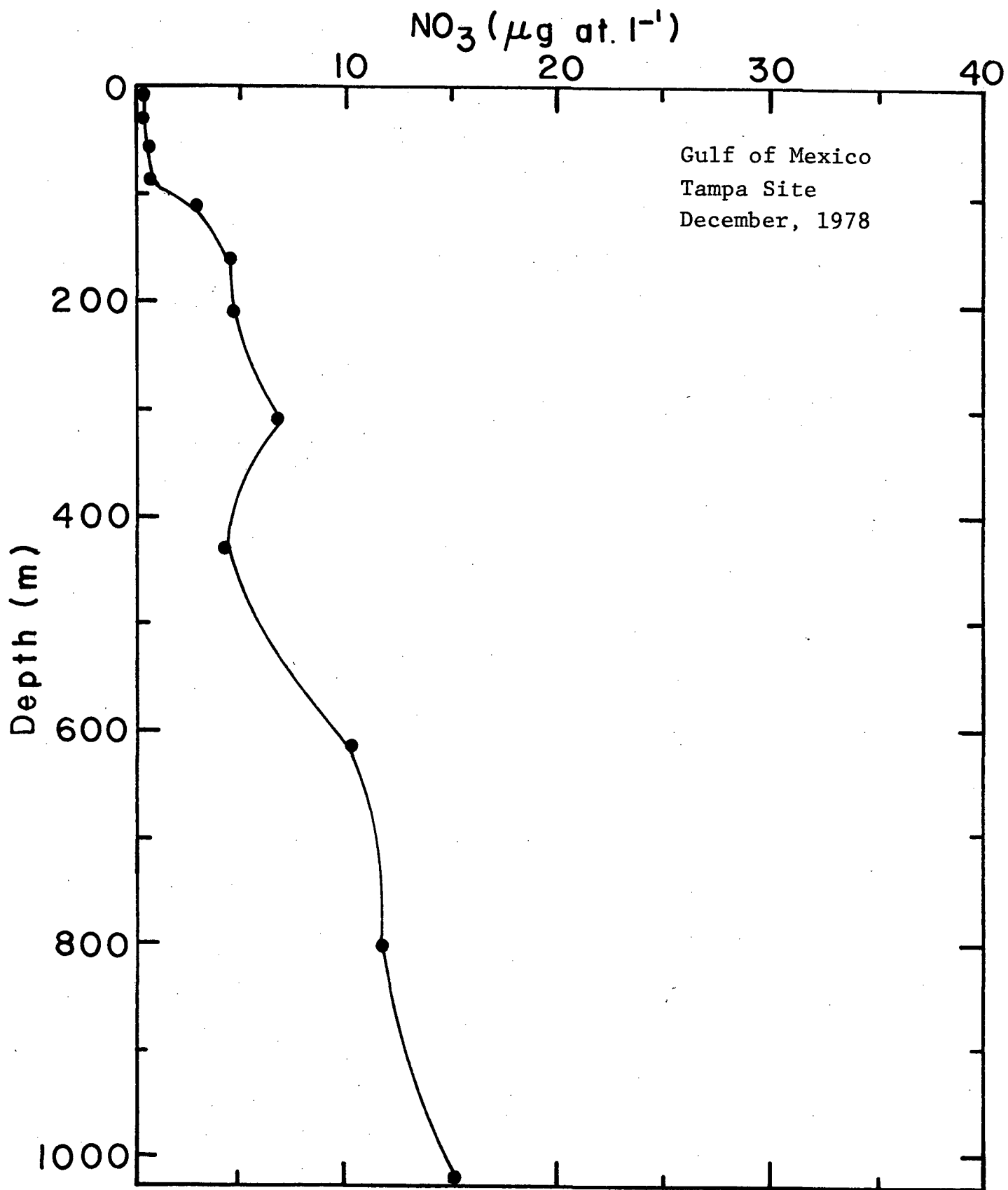


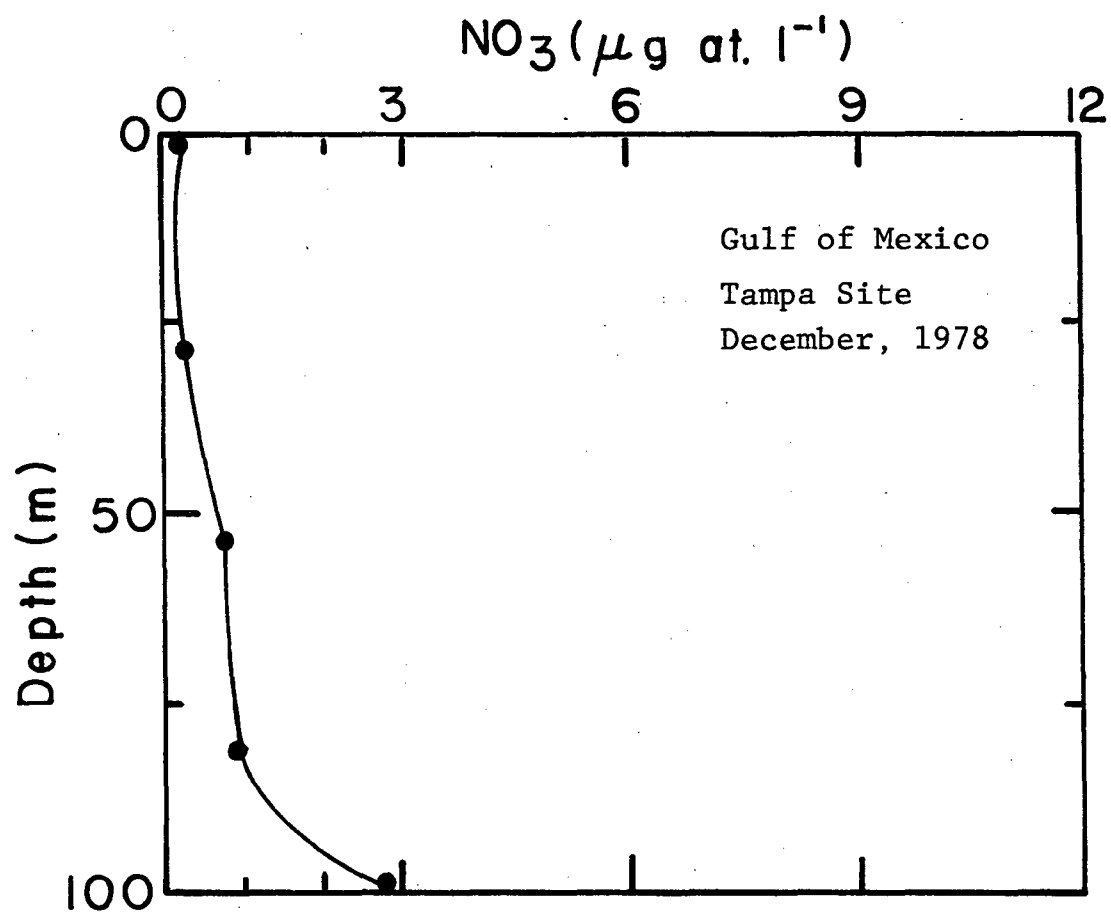
GULF OF MEXICO - TAMPA SITE

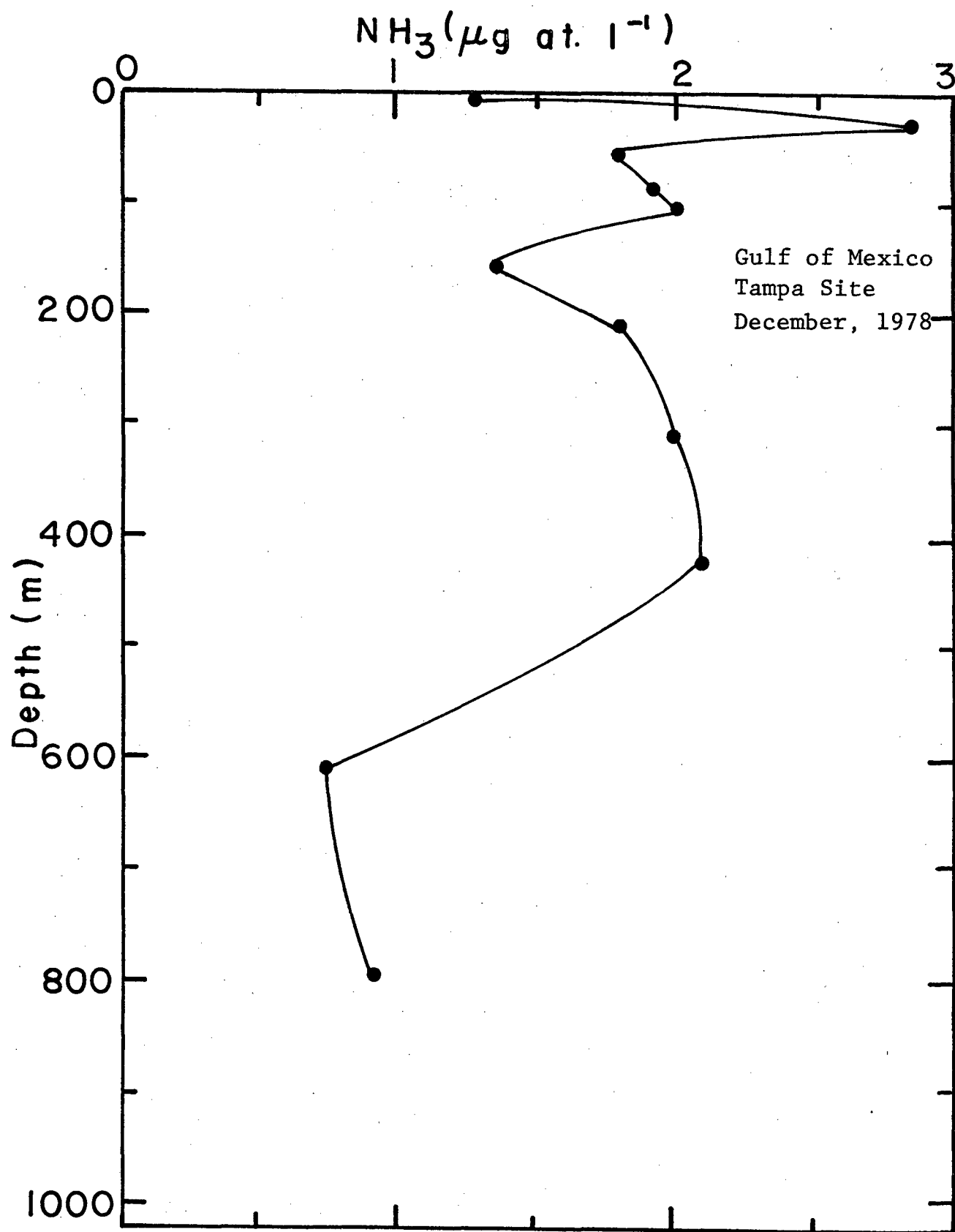
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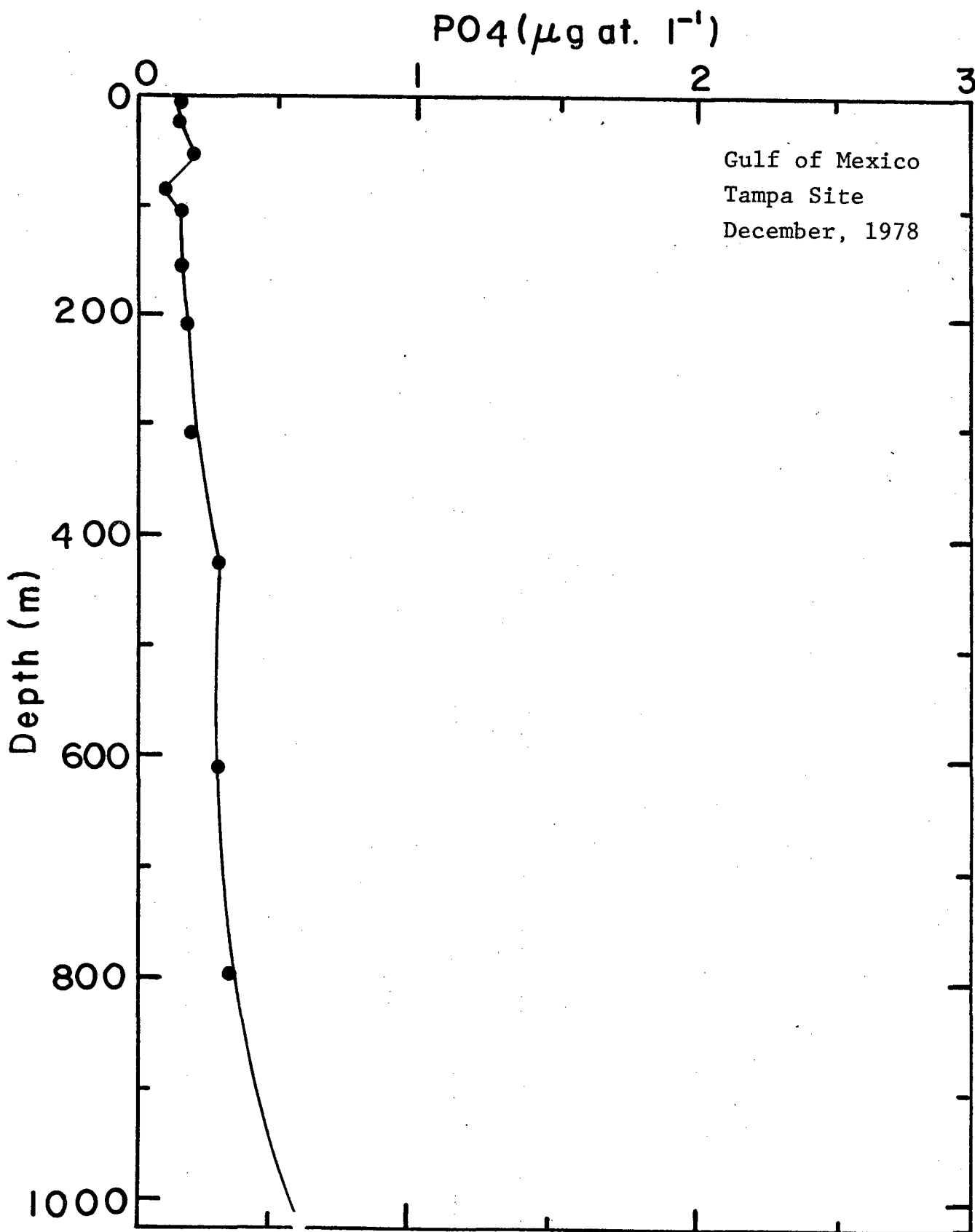
Depth (Corrected m)	O_2 (ml ℓ^{-1})	NO_2 (μg at ℓ^{-1})	NO_3 (μg at ℓ^{-1})	NH_3 (μg at ℓ^{-1})	PO_4 (μg at ℓ^{-1})	ΣPO_4 (μg at ℓ^{-1})	SiO_3 (μg at ℓ^{-1})
2	4.9	0.05	0.25	1.3	0.15	0.22	0.80
29	4.9	0.05	0.25	2.8	0.15	0.24	0.80
54	4.9	0.05	0.75	1.8	0.20	0.36	0.05
81	4.0	0.05	0.95	1.9	0.10	0.40	0.10
103	3.6	0.08	2.9	2.0	0.15	0.63	0.10
156	3.2	0.10	4.4	1.4	0.15	0.60	0
208	3.3	0.10	4.4	1.8	0.18	0.63	0.50
304	3.0	0.10	6.9	2.0	0.20	0.67	0
423	2.9	0.10	4.4	2.1	0.30	0.94	1.0
608	3.1	0.10	10	0.75	0.30	0.96	2.0
797	3.6	0.10	12	0.92	0.35	1.1	4.0
1025	-	0.05	15	-	0.60	1.3	5.0

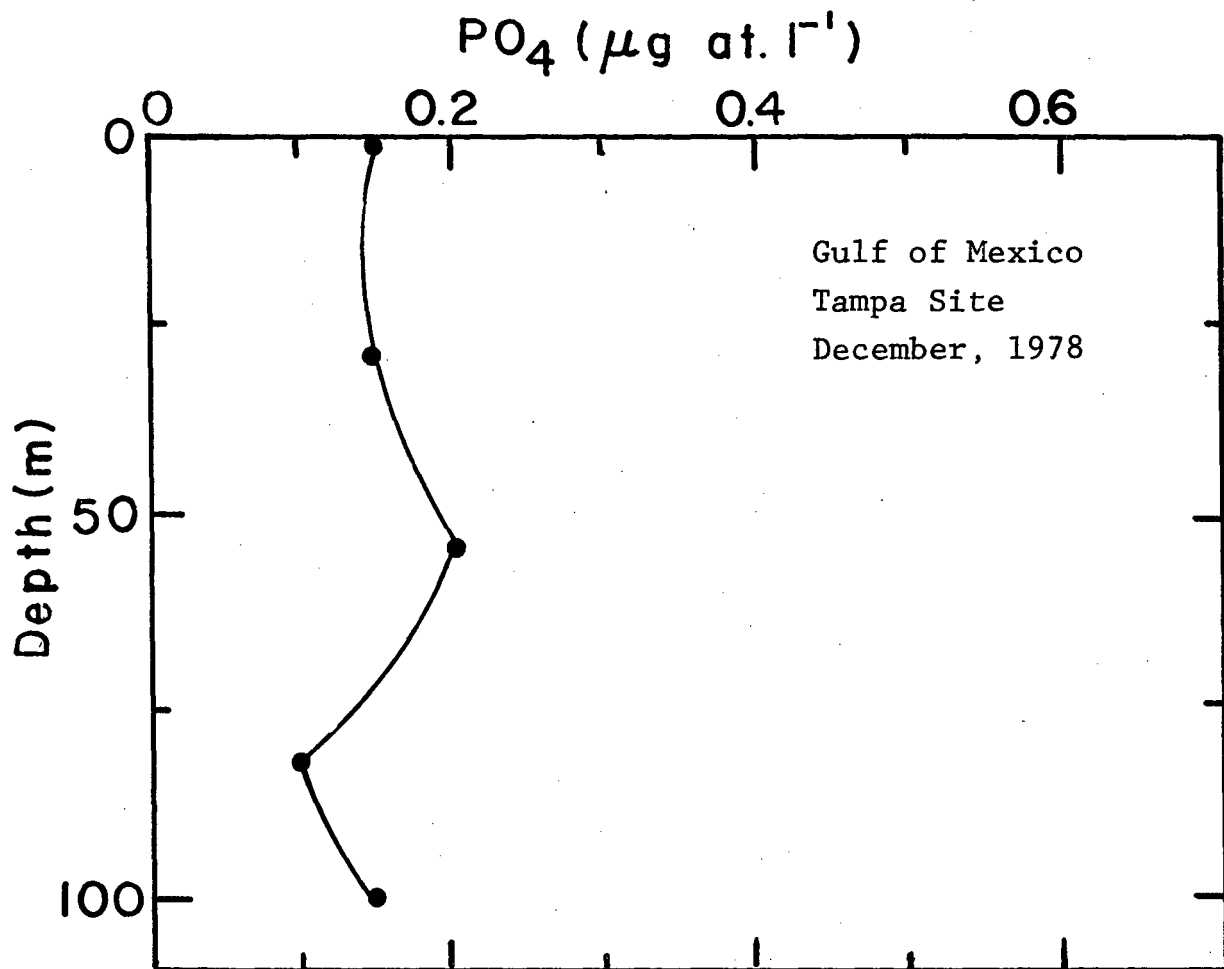


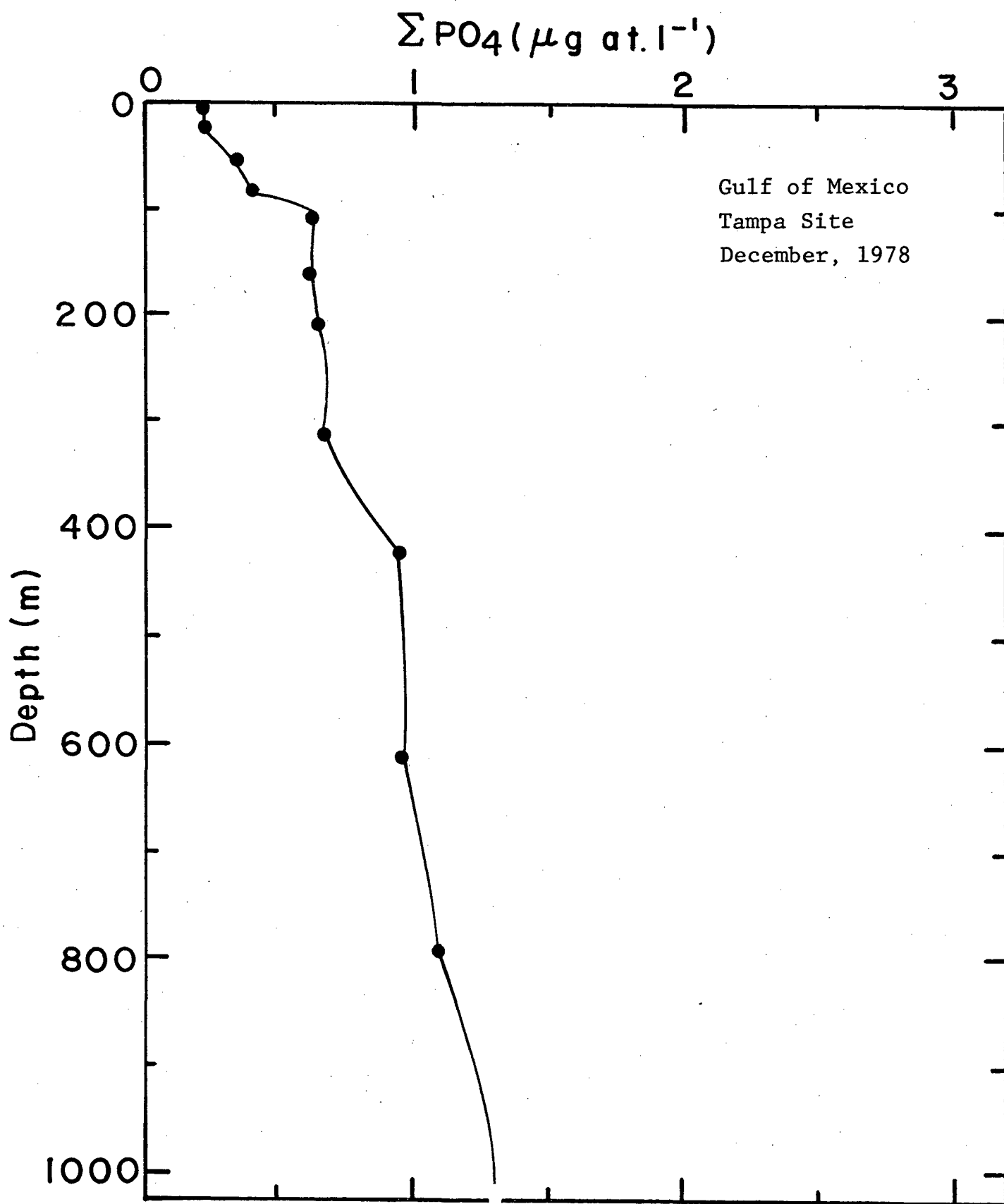


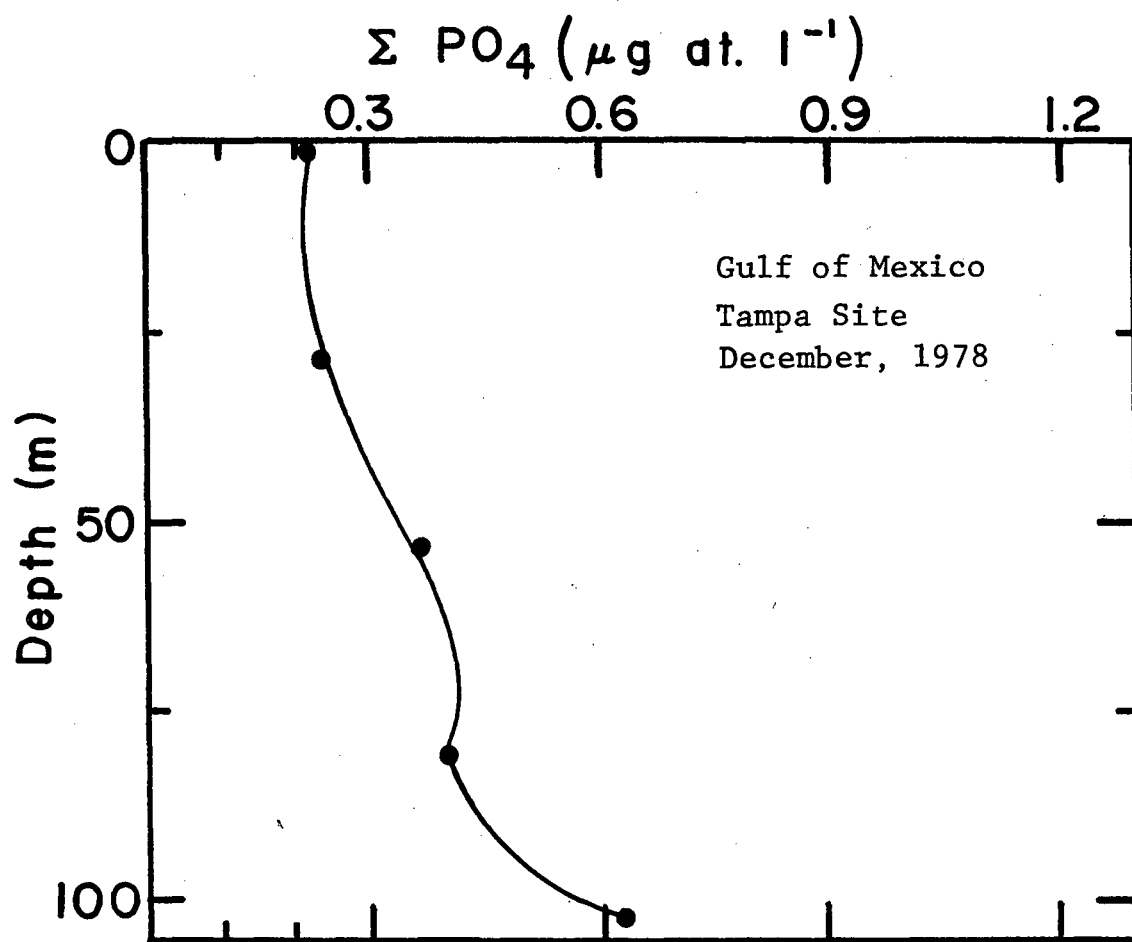


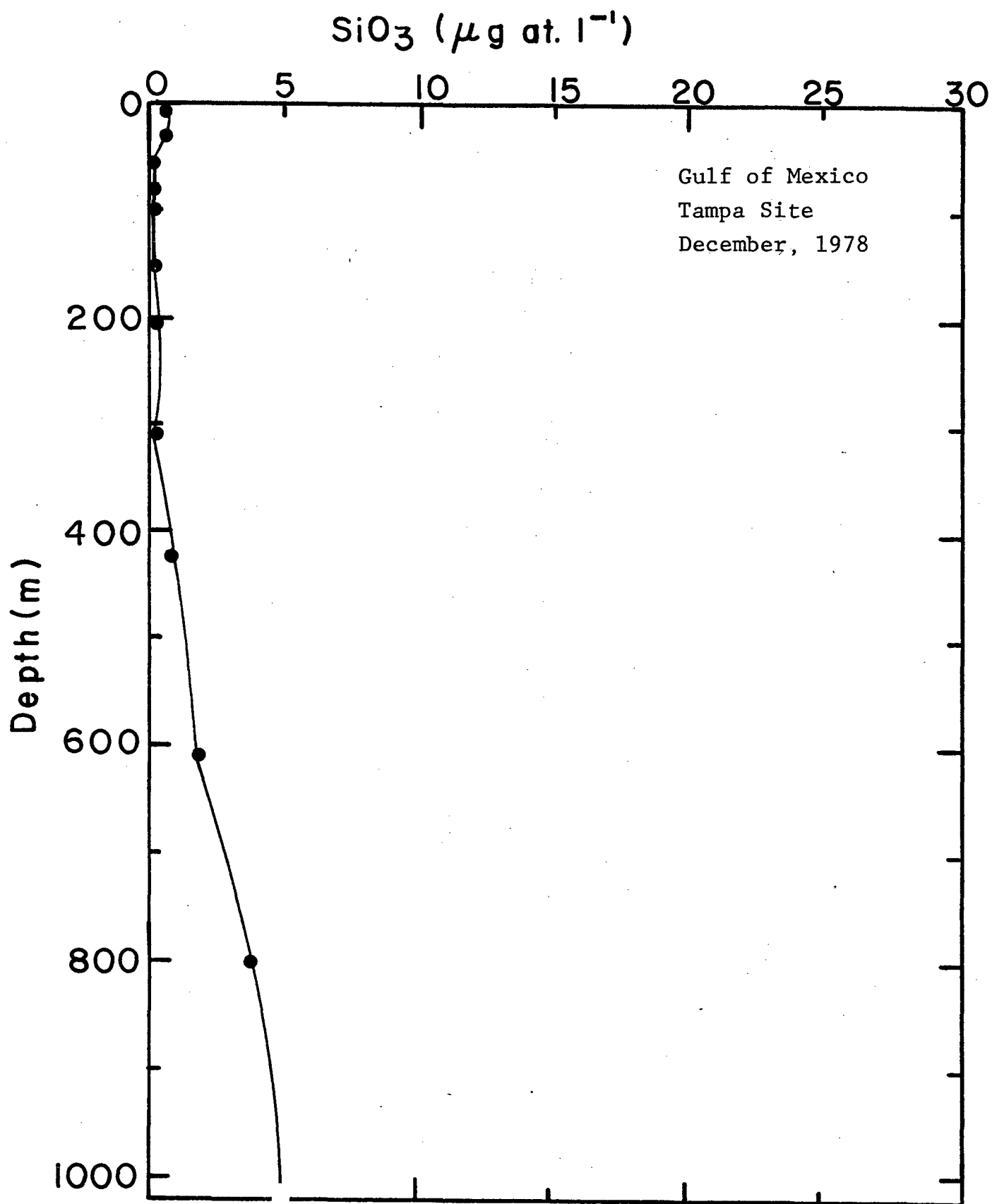


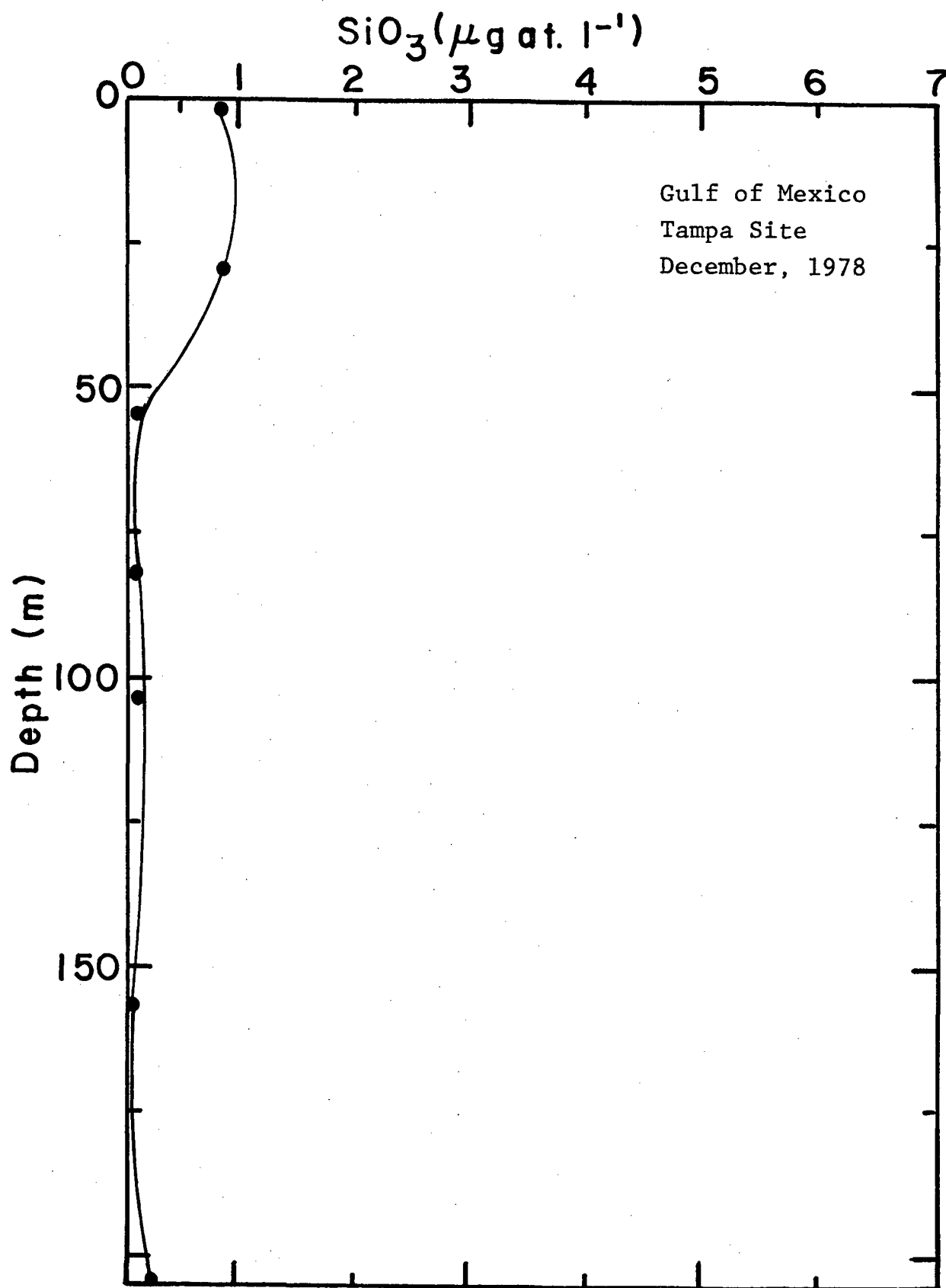












GULF OF MEXICO - TAMPA SITE

STATION 4

2/15/79

0500 Z

27° 36.16'N

85° 29.08'W

Depth (Corrected m)	O ₂ (ml l ⁻¹)	NO ₂ (μg at l ⁻¹)	NO ₃ (μg at l ⁻¹)	NH ₃ (μg at l ⁻¹)	PO ₄ (μg at l ⁻¹)	Σ PO ₄ (μg at l ⁻¹)	SiO ₃ (μg at l ⁻¹)
0	5.4	0	0	0.30	0	0.09	0
25	4.9	0.09	0.52	0.34	0	0.22	0
50	5.4	0.17	0.69	0.59	0	0.40	0
75	4.6	0.24	3.0	0.30	0.30	0.69	0.92
98	3.6	0	11	0.16	0.69	1.1	2.4
151	3.5	0	15	0.19	0.93	1.4	4.9
200	3.3	0*	7.7 *	0.30	0.53*	1.8	0.55*
300	3.6	0	26	0.19	1.6	2.1	12
400	3.3	0	31	0.42	1.9	2.9	16
600	3.6	0	33	0.42	2.1	3.0	21
801	4.0	0	31	0.43	1.9	2.9	23
1001	4.2	0	28	0.57	1.8	2.8	24

*Appears to not have been preserved.

GULF OF MEXICO - TAMPA SITE

STATION 8

2/15/79

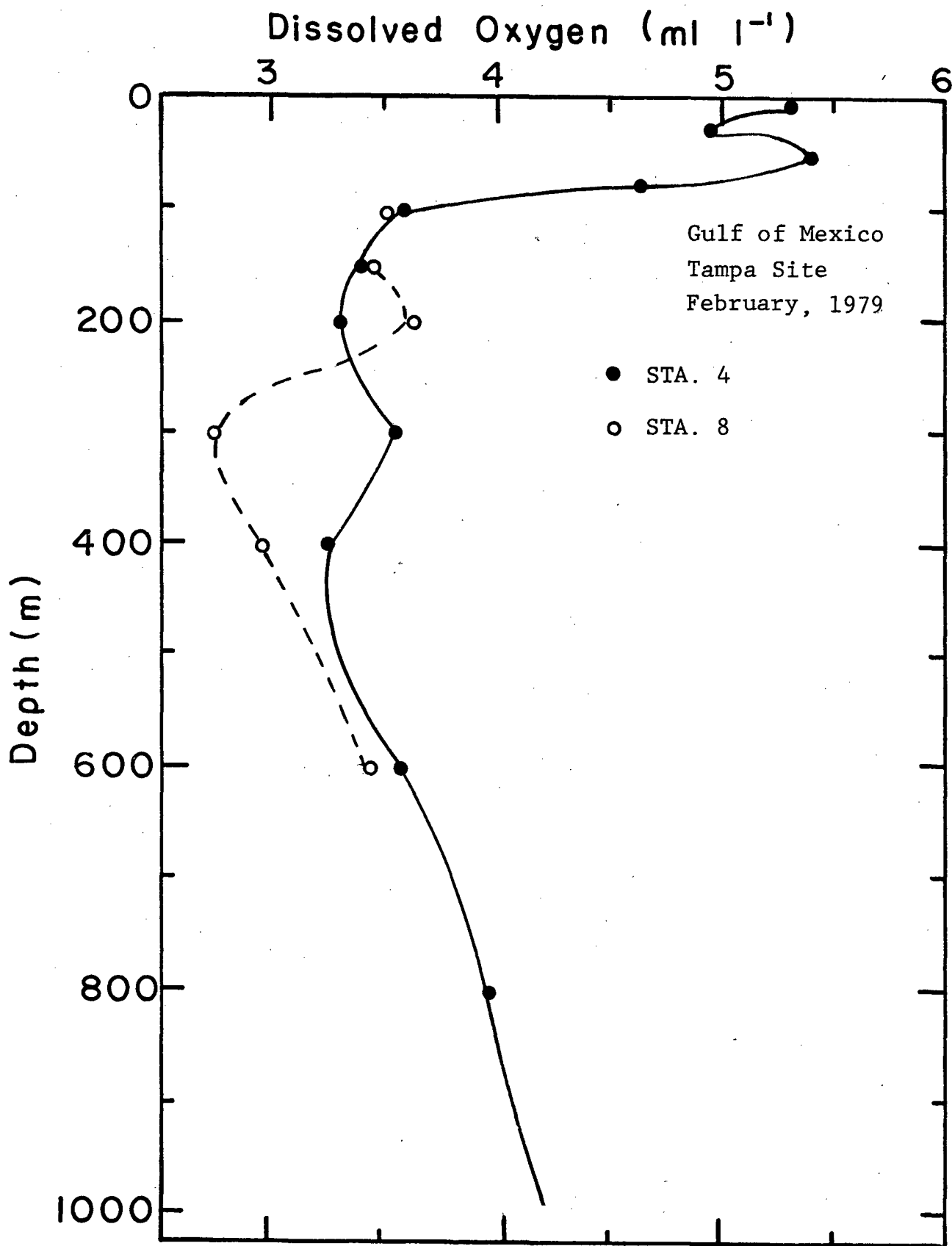
2014 Z

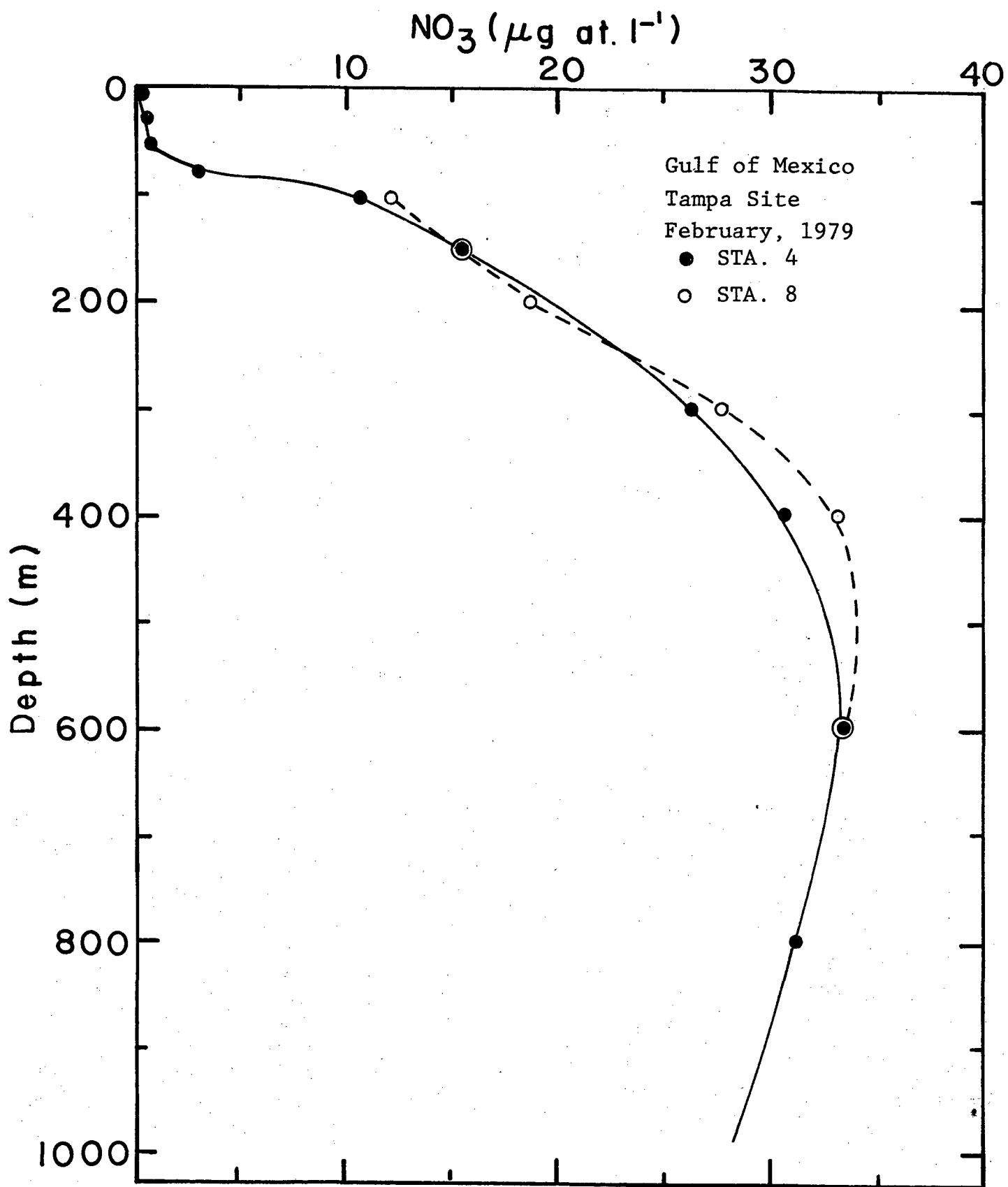
27° 38.56'N

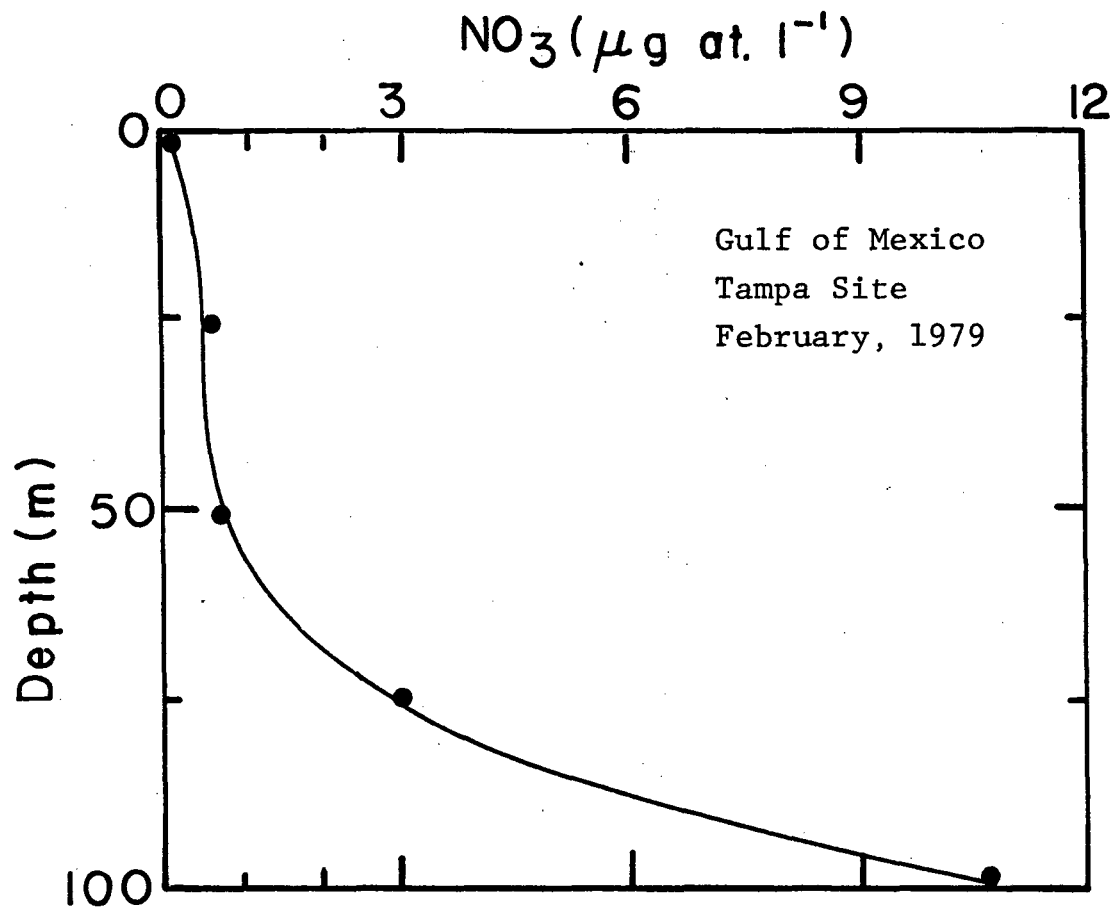
85° 33.21'W

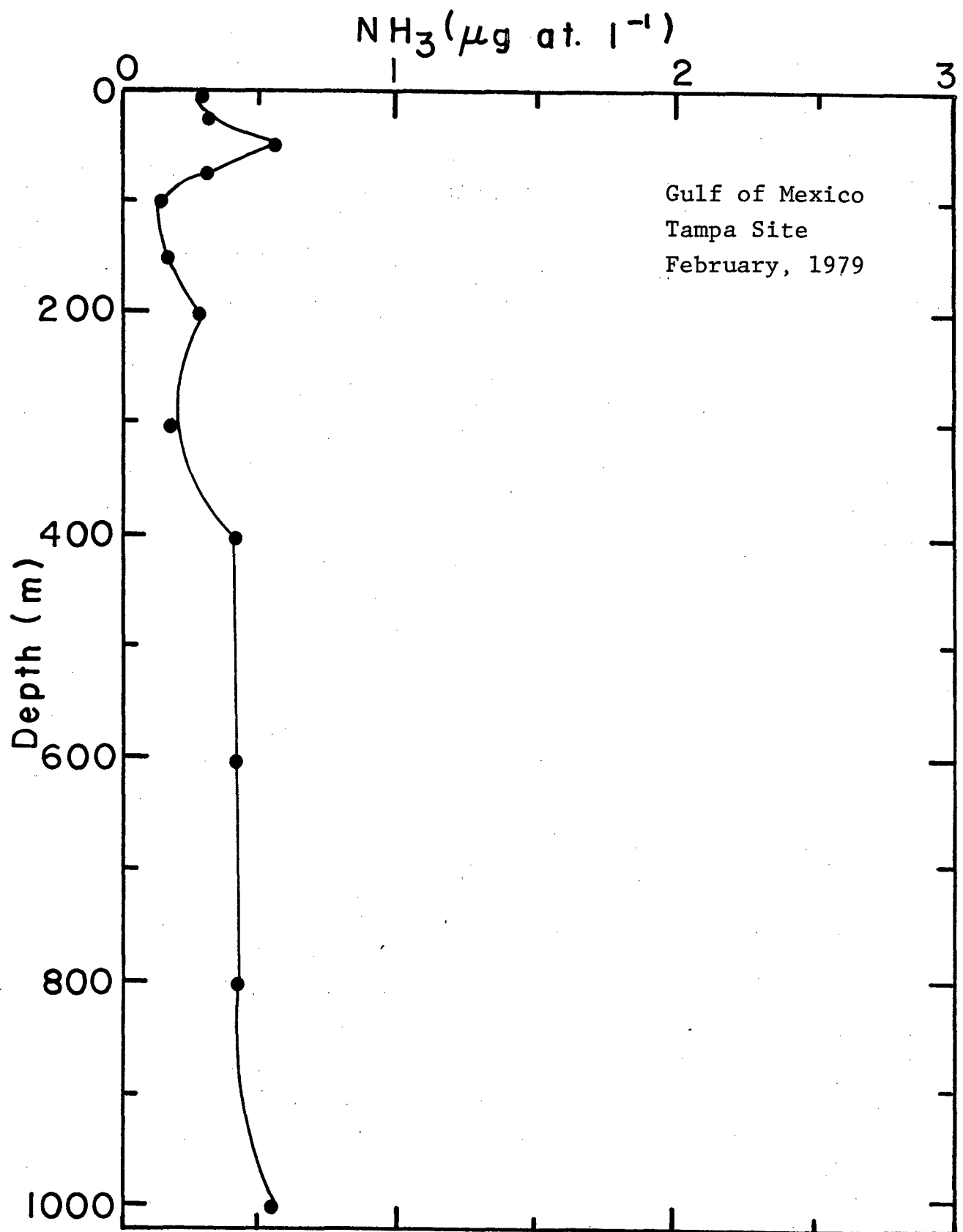
Depth (Corrected m)	O ₂ (ml l ⁻¹)	NO ₂ (μg at l ⁻¹)	NO ₃ (μg at l ⁻¹)	NH ₃ * (μg at l ⁻¹)	PO ₄ (μg at l ⁻¹)	ΣPO ₄ (μg at l ⁻¹)	SiO ₃ (μg at l ⁻¹)
100	3.5	0	12	0.030	0.66	1.1	3.0
150	3.5	0.05	15	0.033	0.78	1.4	4.7
200	3.6	0	19	0.055	1.1	1.8	6.6
300	2.8	0	27	0.055	1.6	2.0	12
400	2.9	0	33	0.080	2.1	2.9	21
600	3.5	0	33	0.13	2.	3.0	21

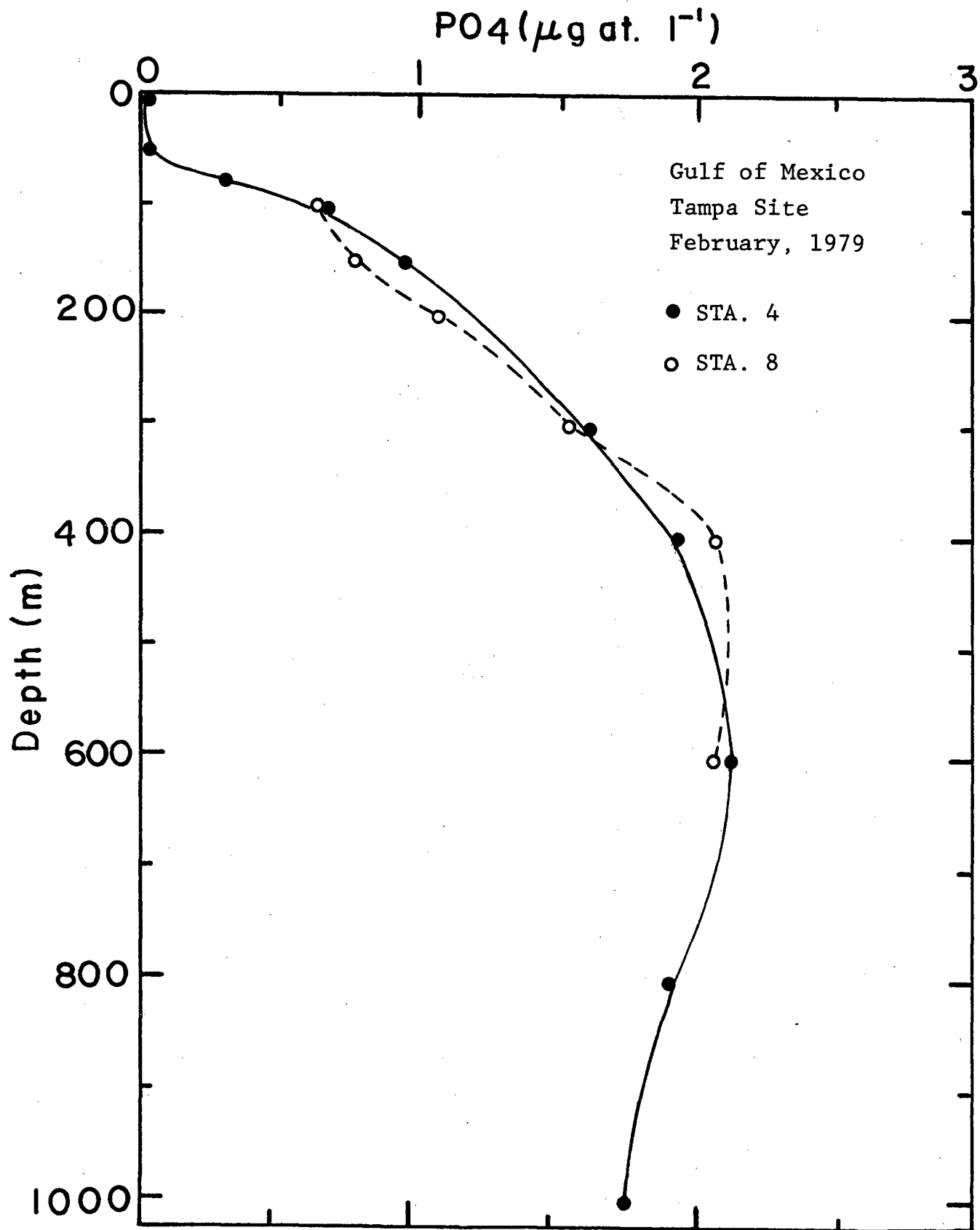
* Allowed to thaw and sit during transport.

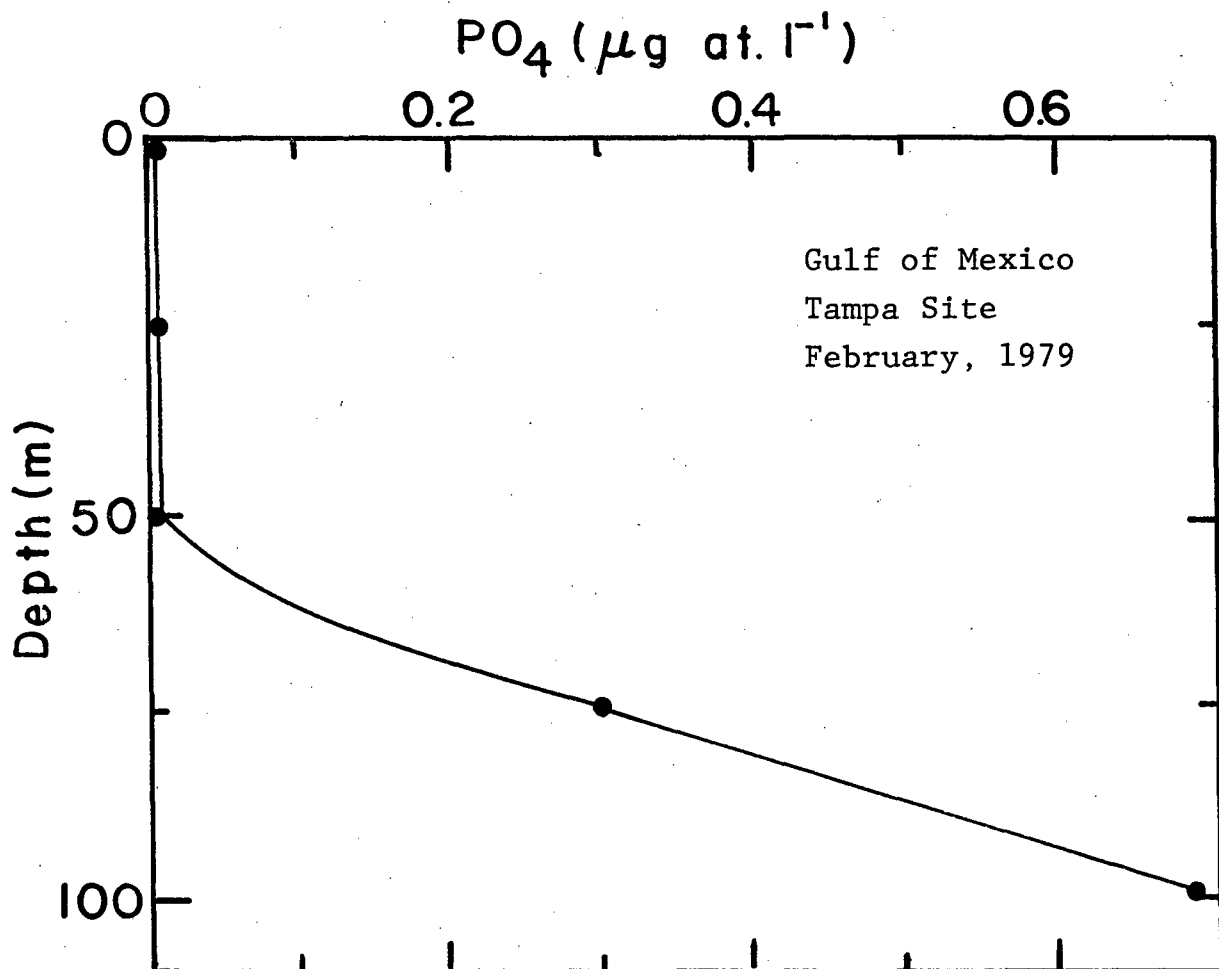


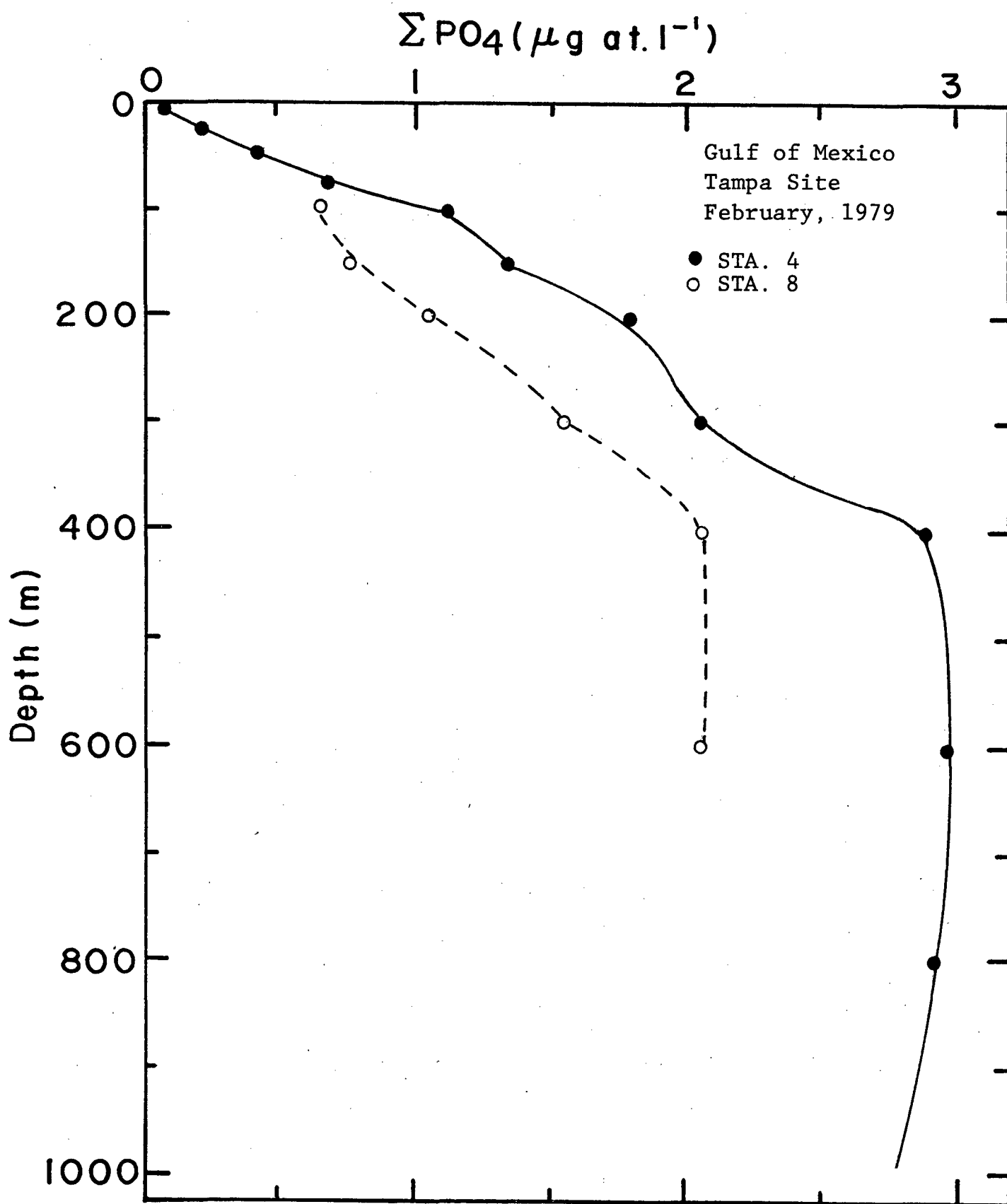


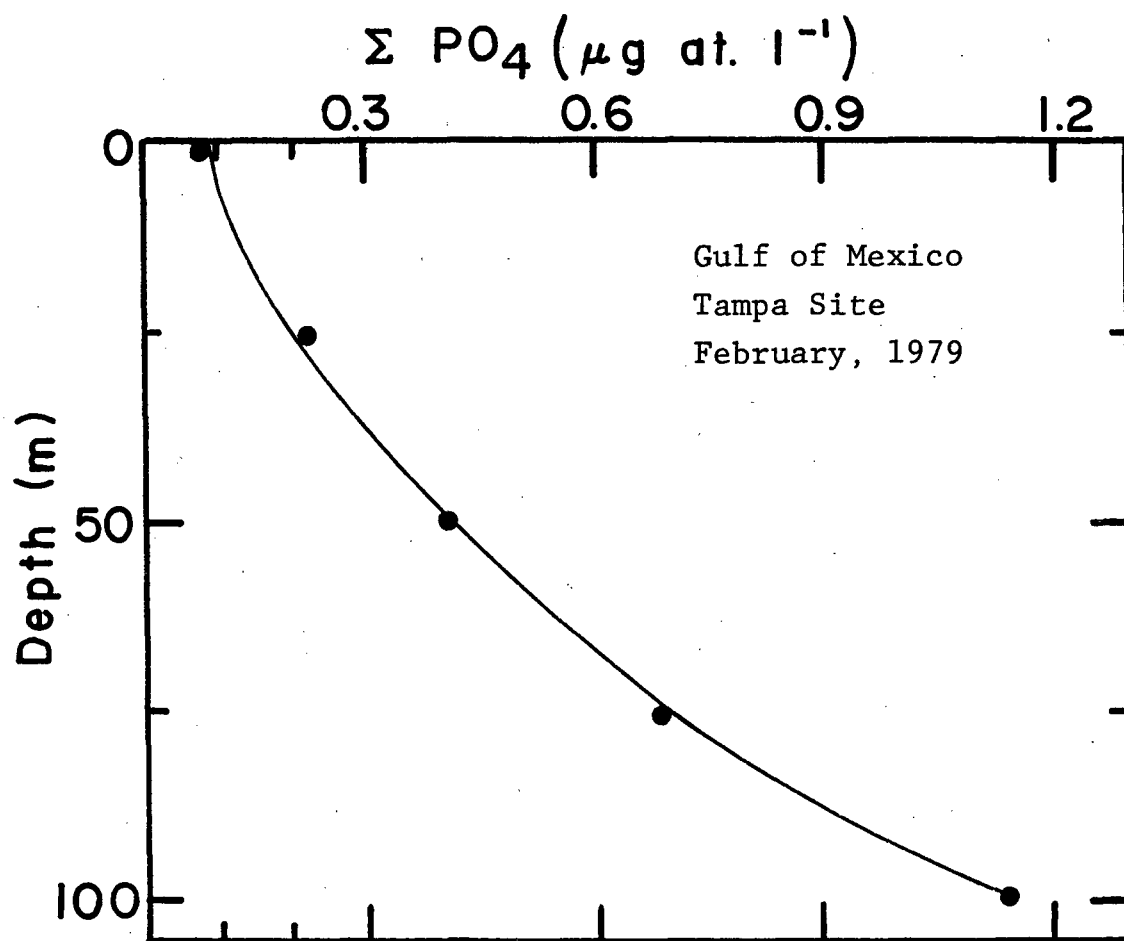


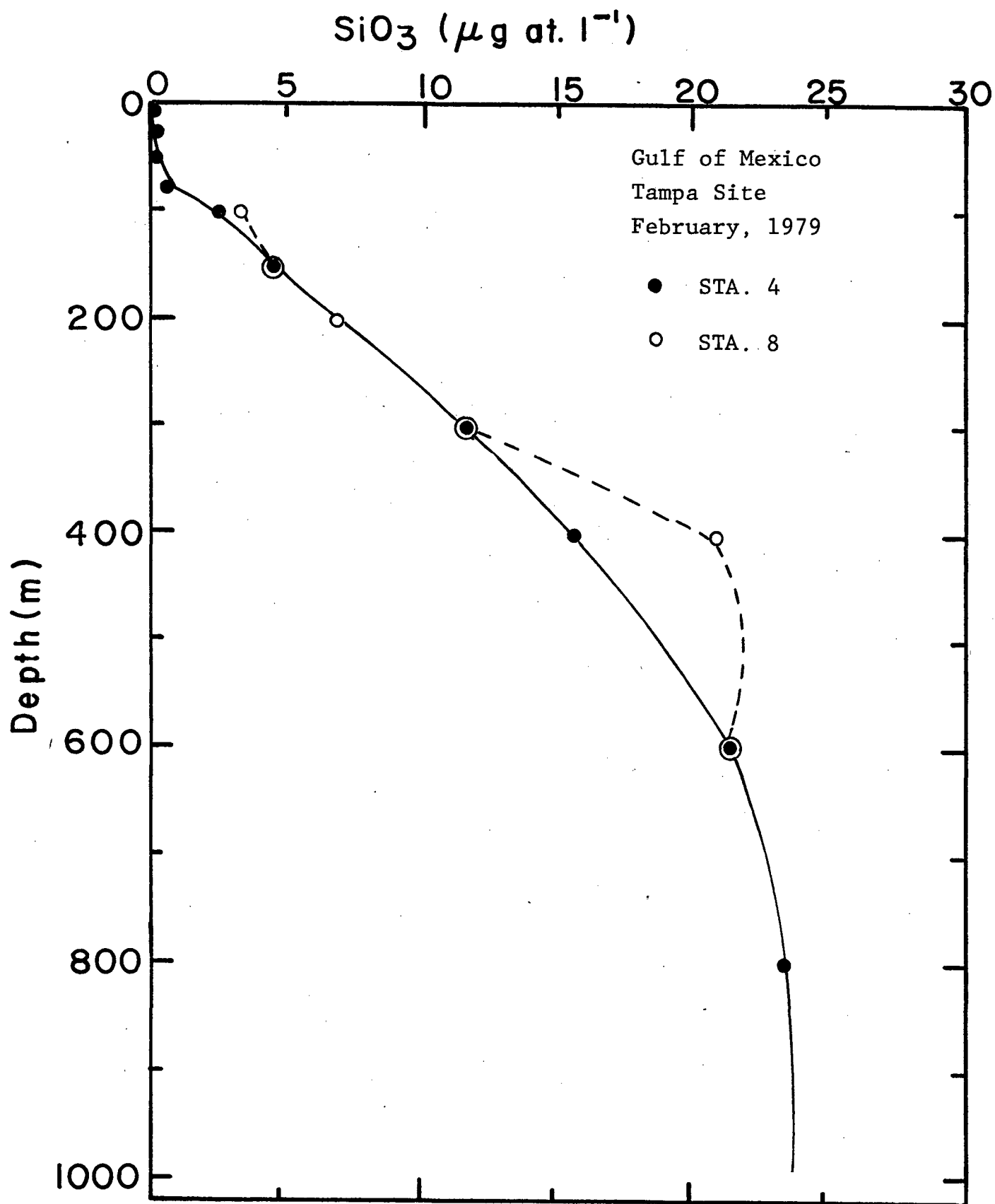


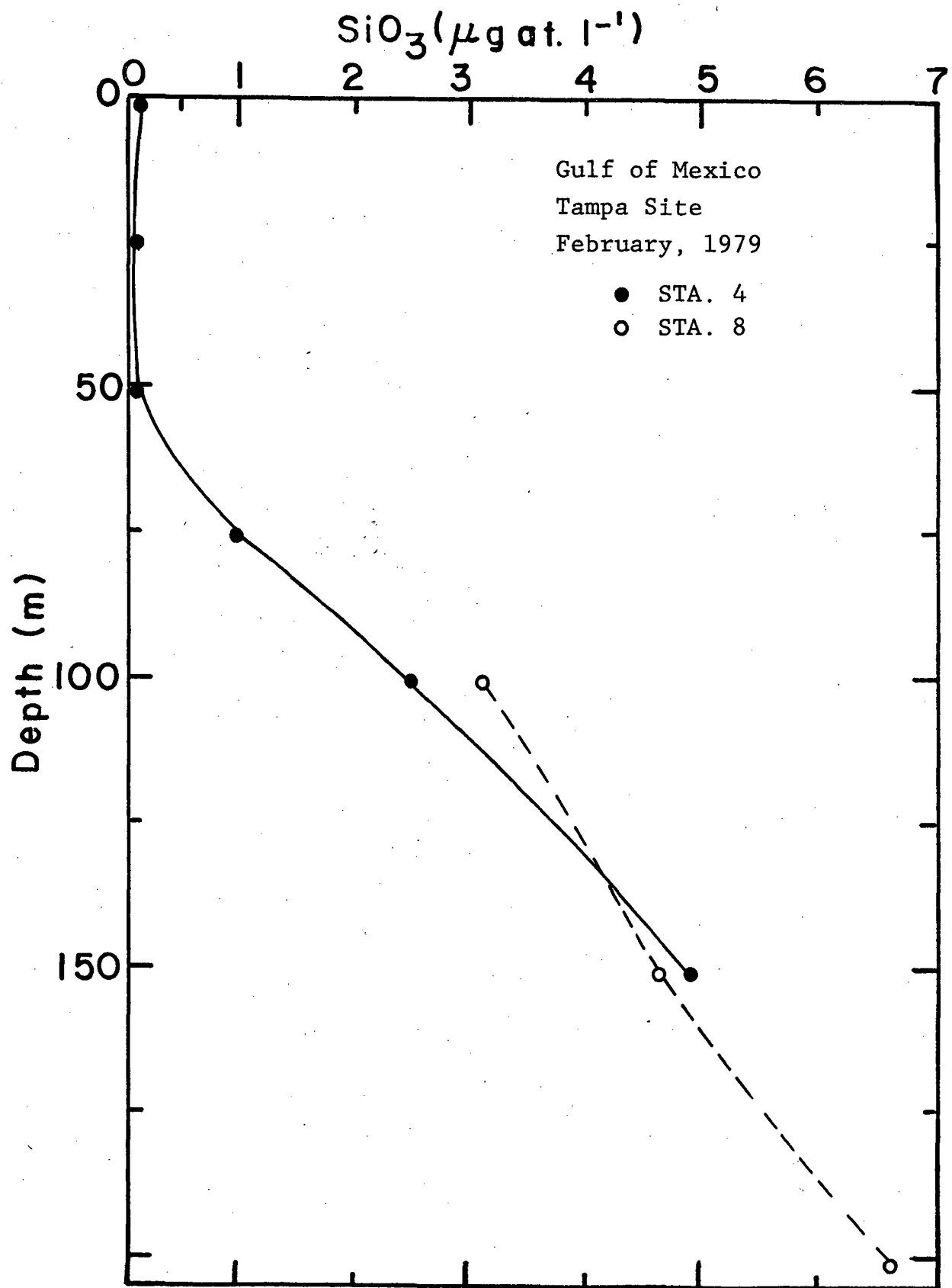












GULF OF MEXICO - TAMPA SITE

STATION 016

4/28/79

1910Z

27°38'N

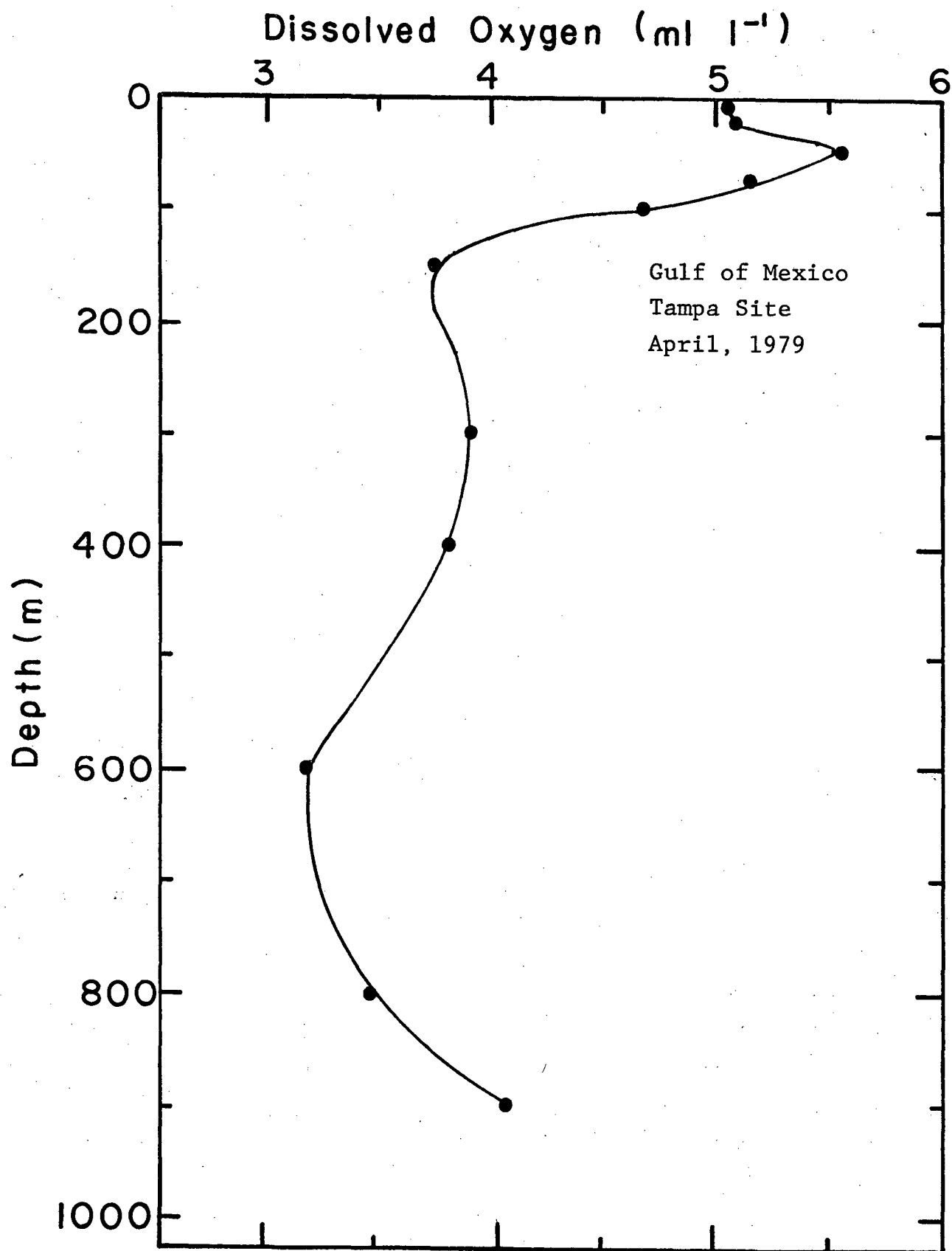
86°30'W

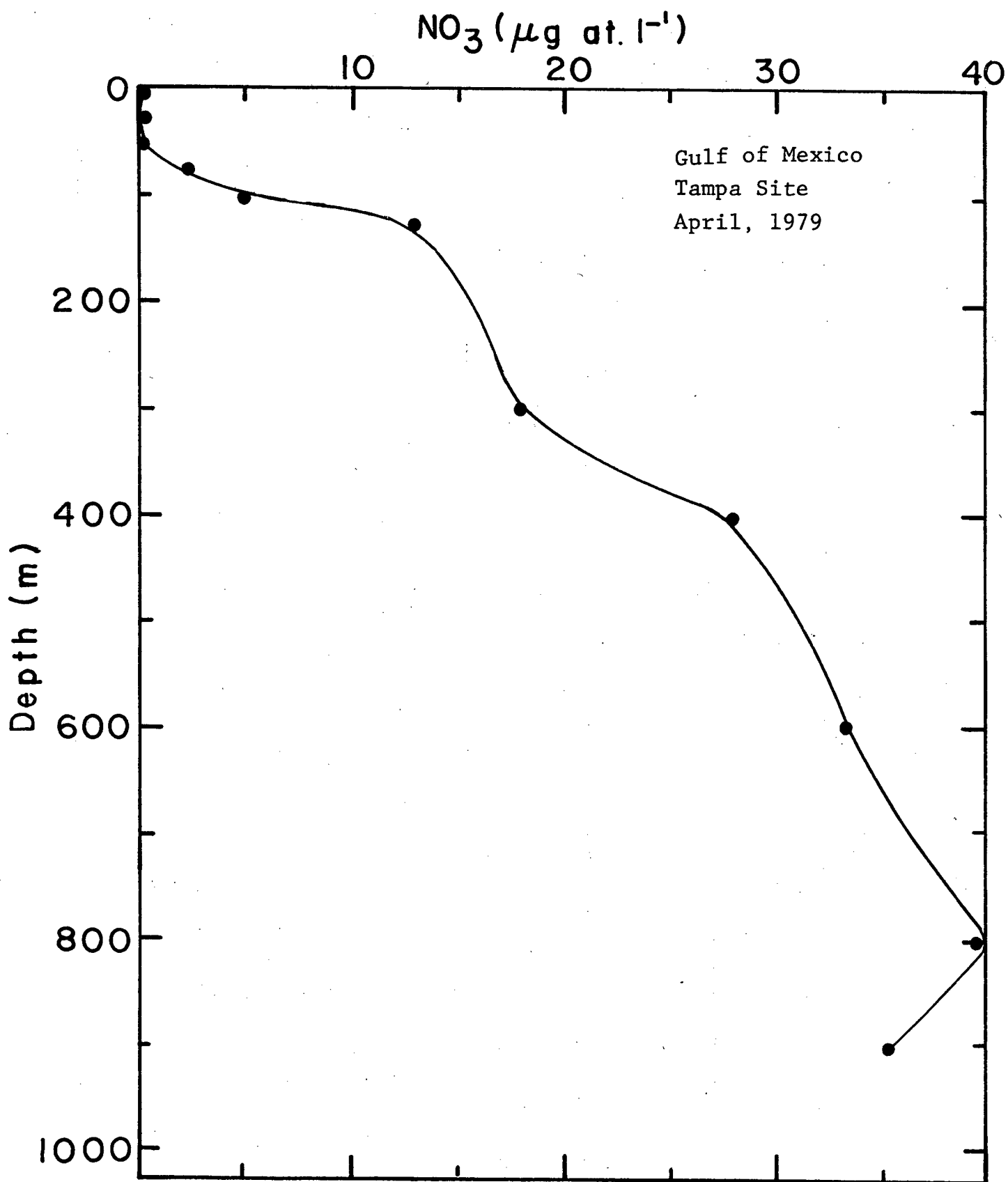
Depth (uncorrected m)	O ₂ (ml l ⁻¹)	NO ₂ (μg at l ⁻¹)	NO ₃ (μg at l ⁻¹)	NH ₃ (μg at l ⁻¹)	PO ₄ (μg at l ⁻¹)	Σ PO ₄ ^{**} (μg at l ⁻¹)	SiO ₃ (μg at l ⁻¹)
0	5.1	0	0	0.76	0	0.24	0
25	5.1	0	0	0.97	0	0.42	0
50	5.6	0	0.10	1.0	0	0.22	0
75	5.1	0	2.5	*	0.20	0.65	0.40
100	4.7	0	5.0	0.39	0.50	1.1	0.90
150	3.8	0	13	0.59	0.50	1.1	4.7
300	3.9	0	18	0.78	0.85	1.8	4.9
400	3.8	0.02	27	0.59	1.3	2.8	9.7
600	3.2	0.02	33	0.54	1.7	3.0	13
800	3.5	0	39	0.22	2.4	3.1	22
900	4.0	0.02	35	0.65	2.0	3.1	24

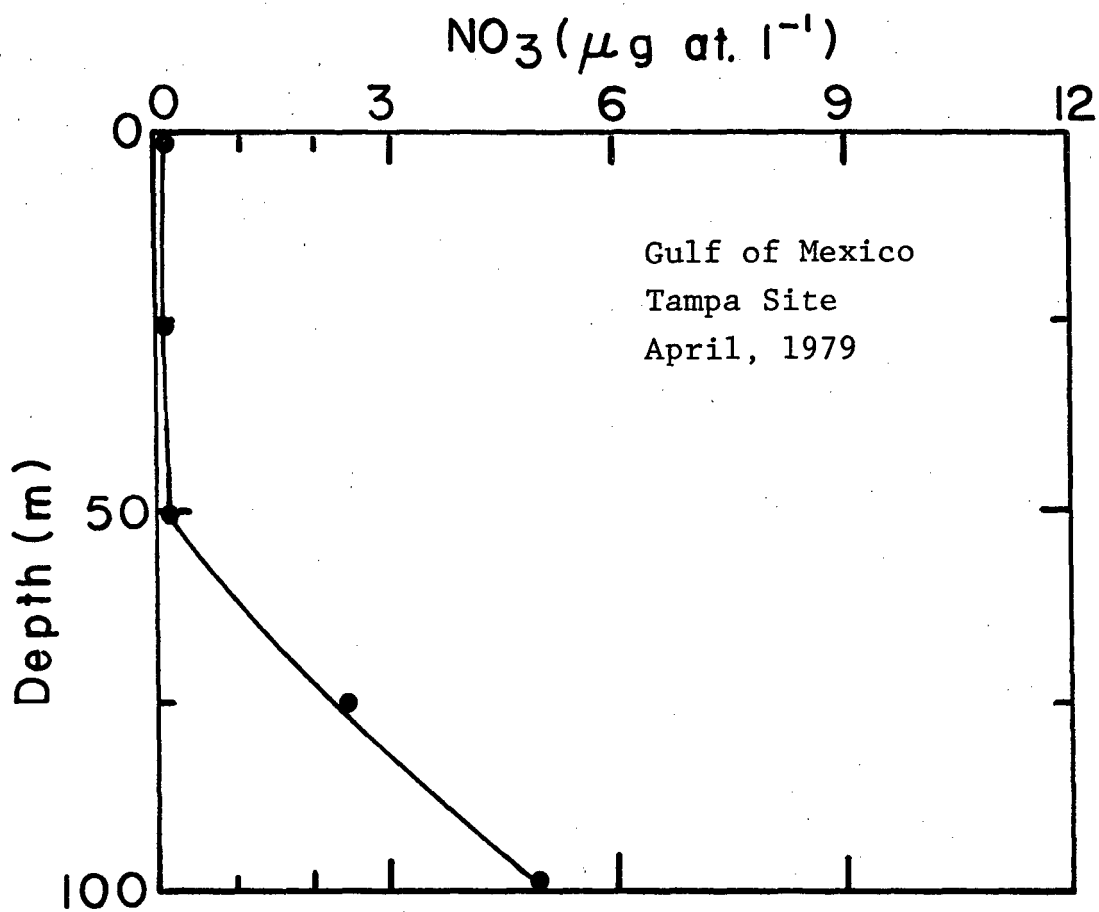
* Sample accidentally destroyed

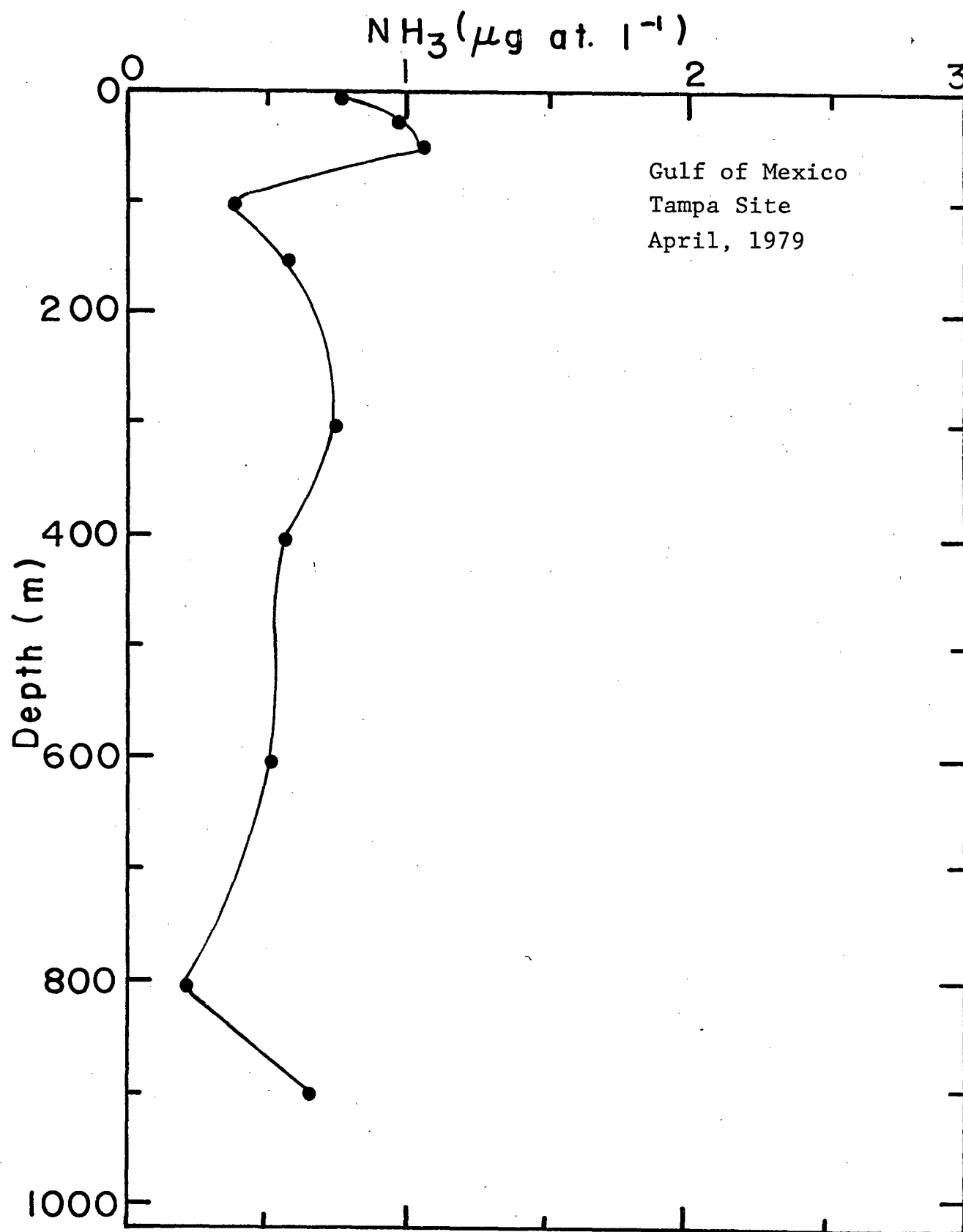
** From plastic nutrient bottles as glass bottles temporarily lost.

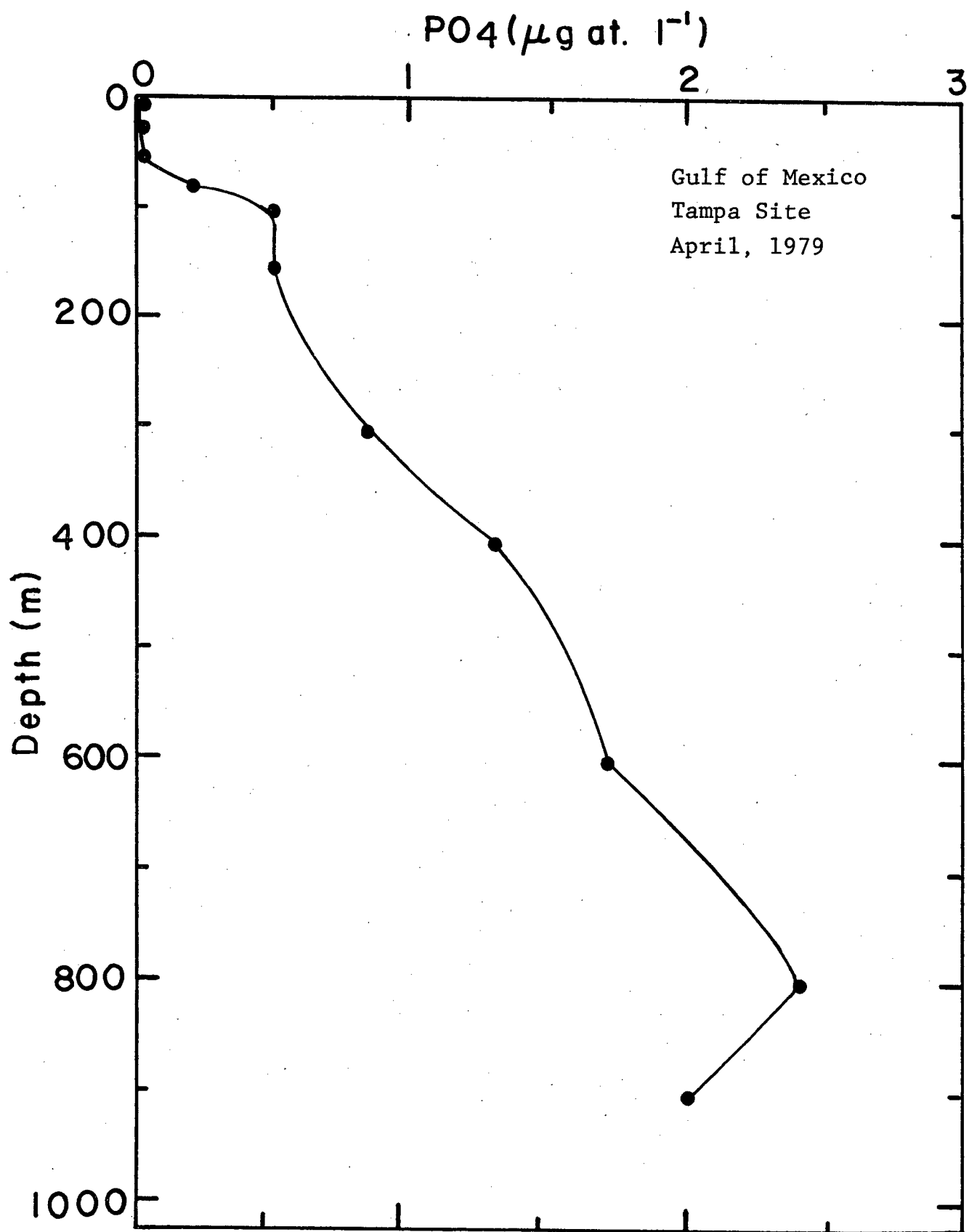
160

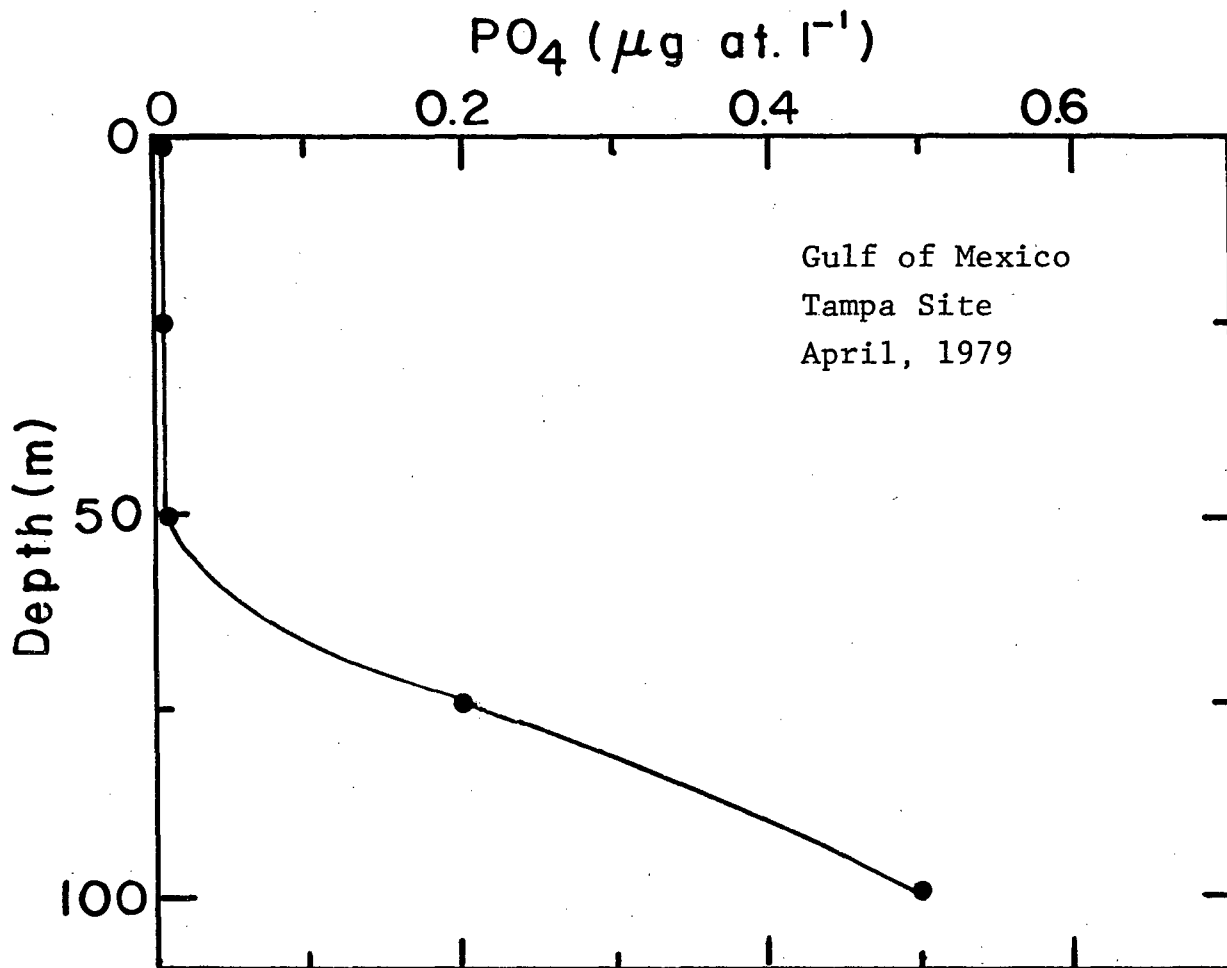


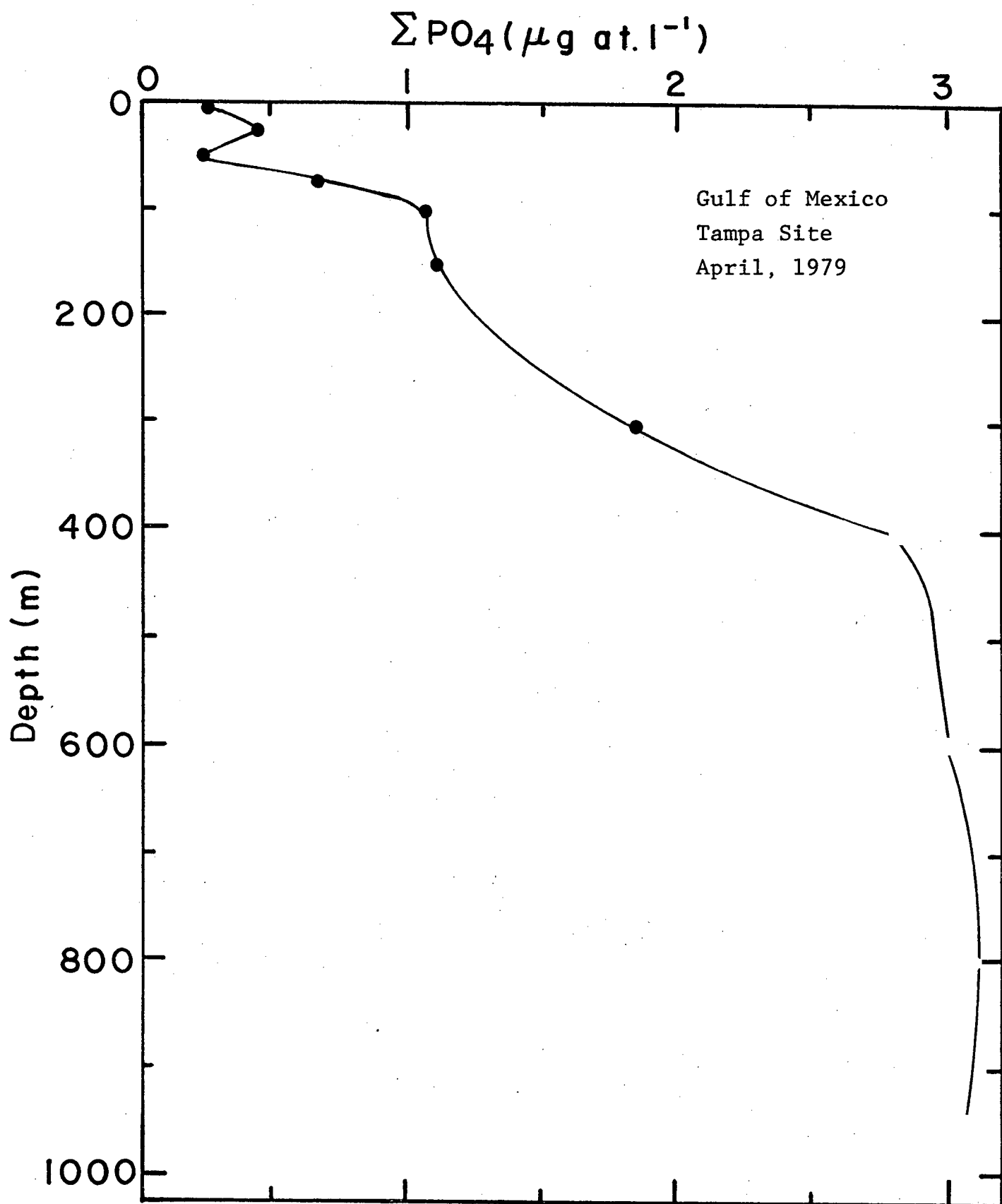


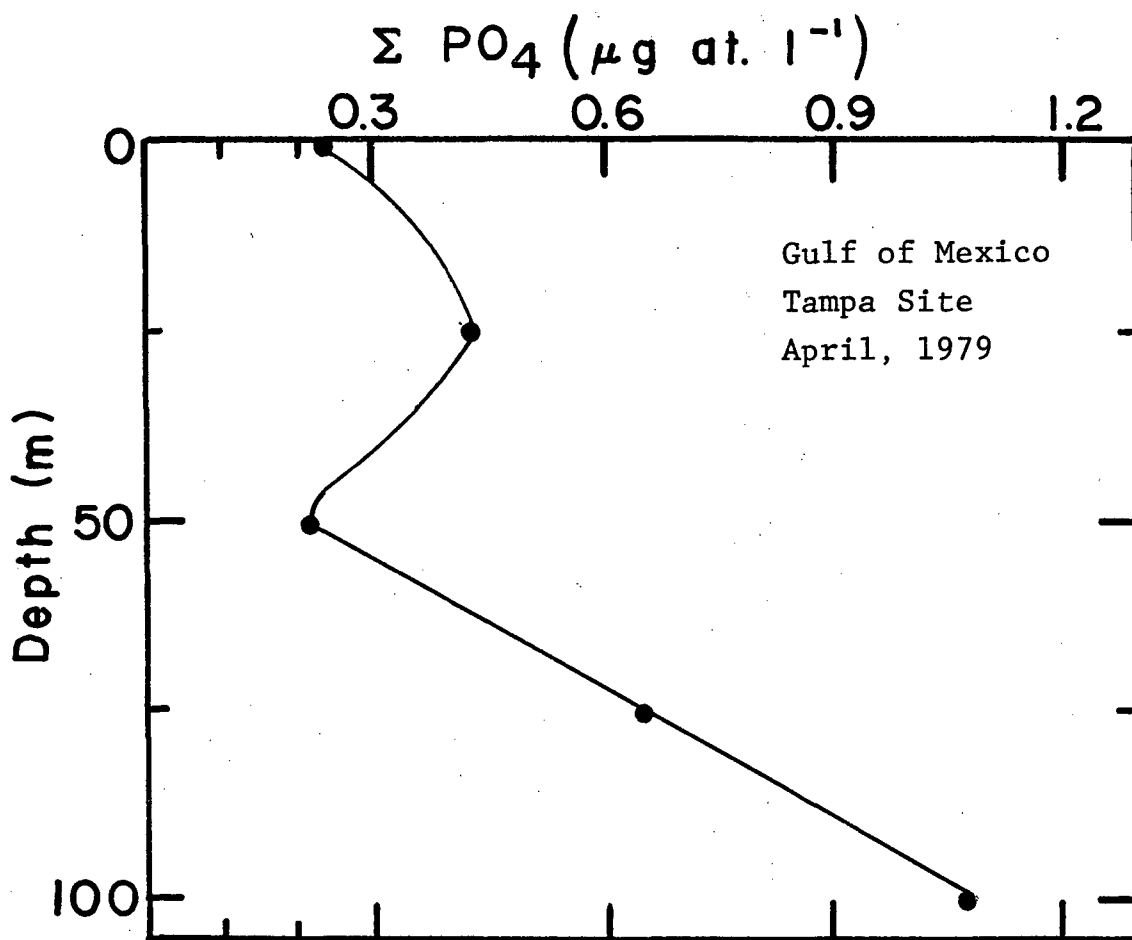


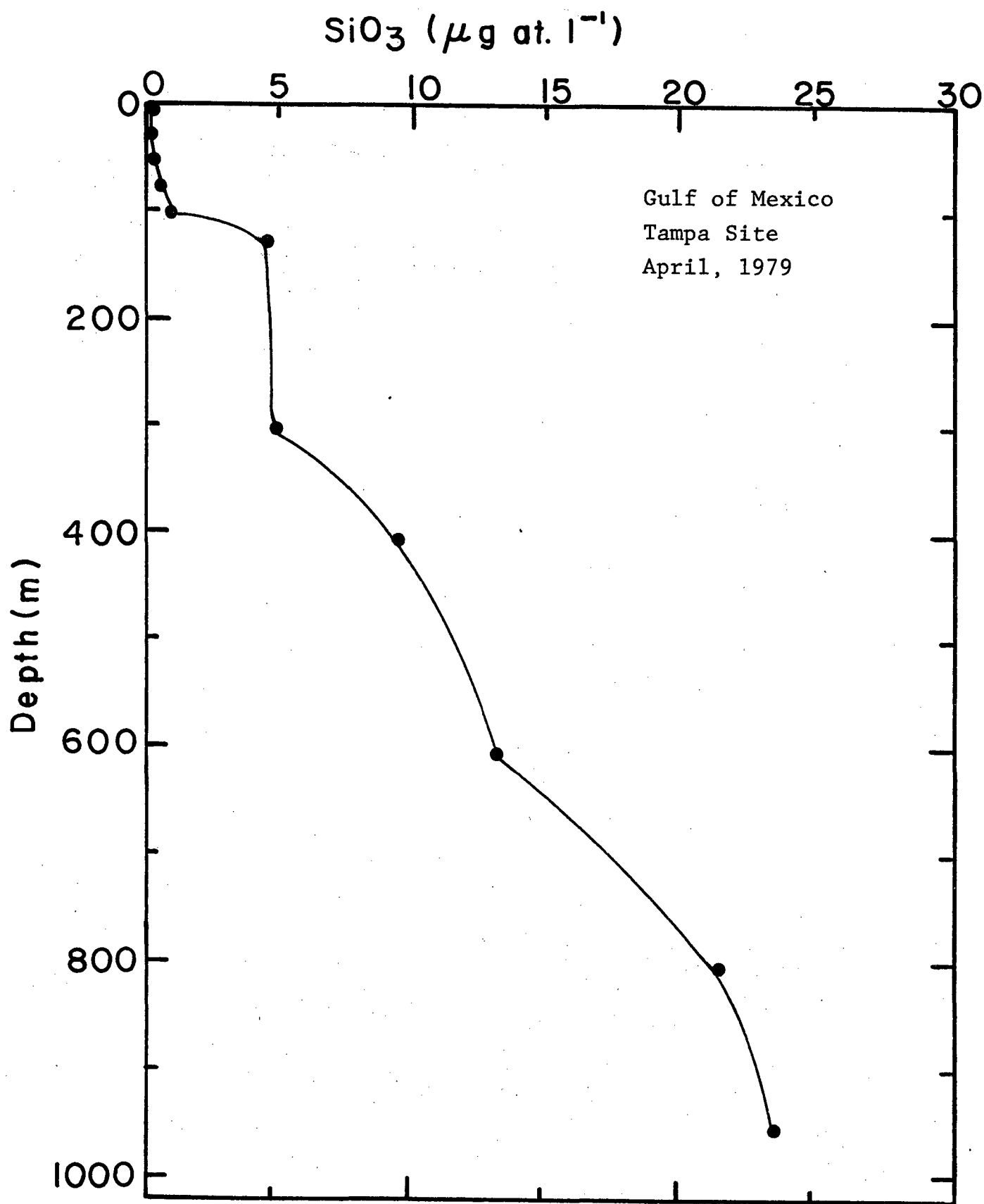


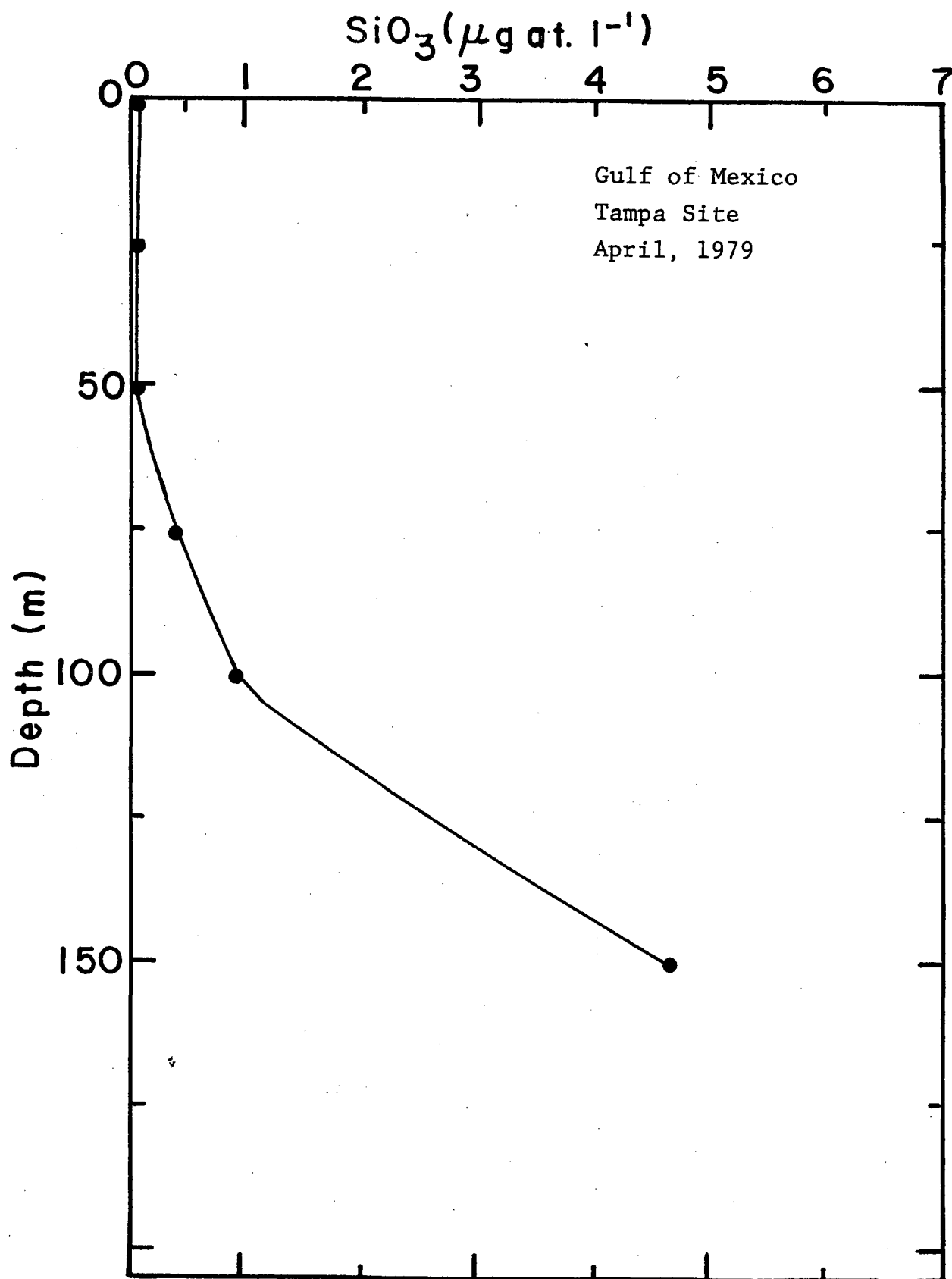












GULF OF MEXICO - TAMPA SITE

STATION 4-5

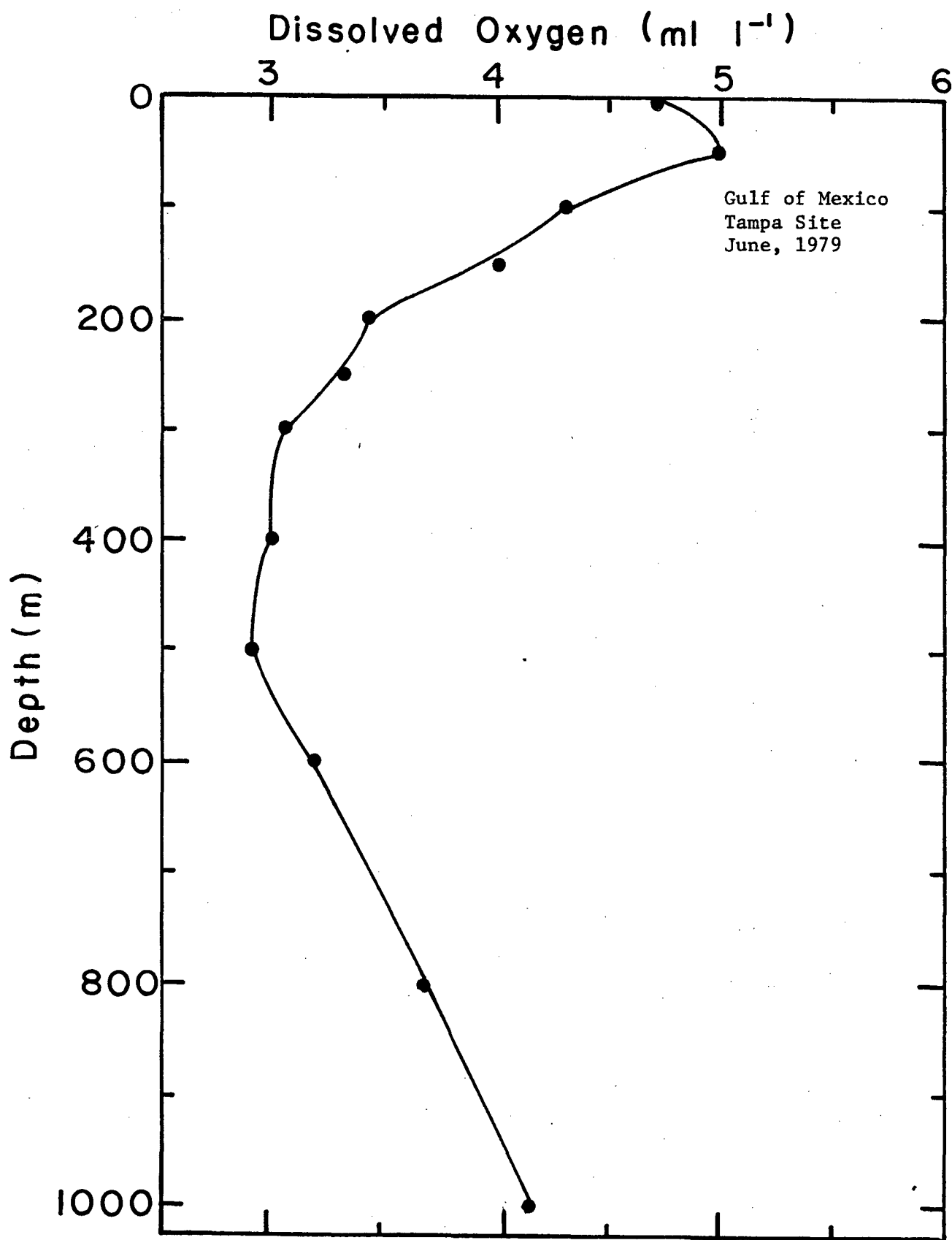
6/28/79

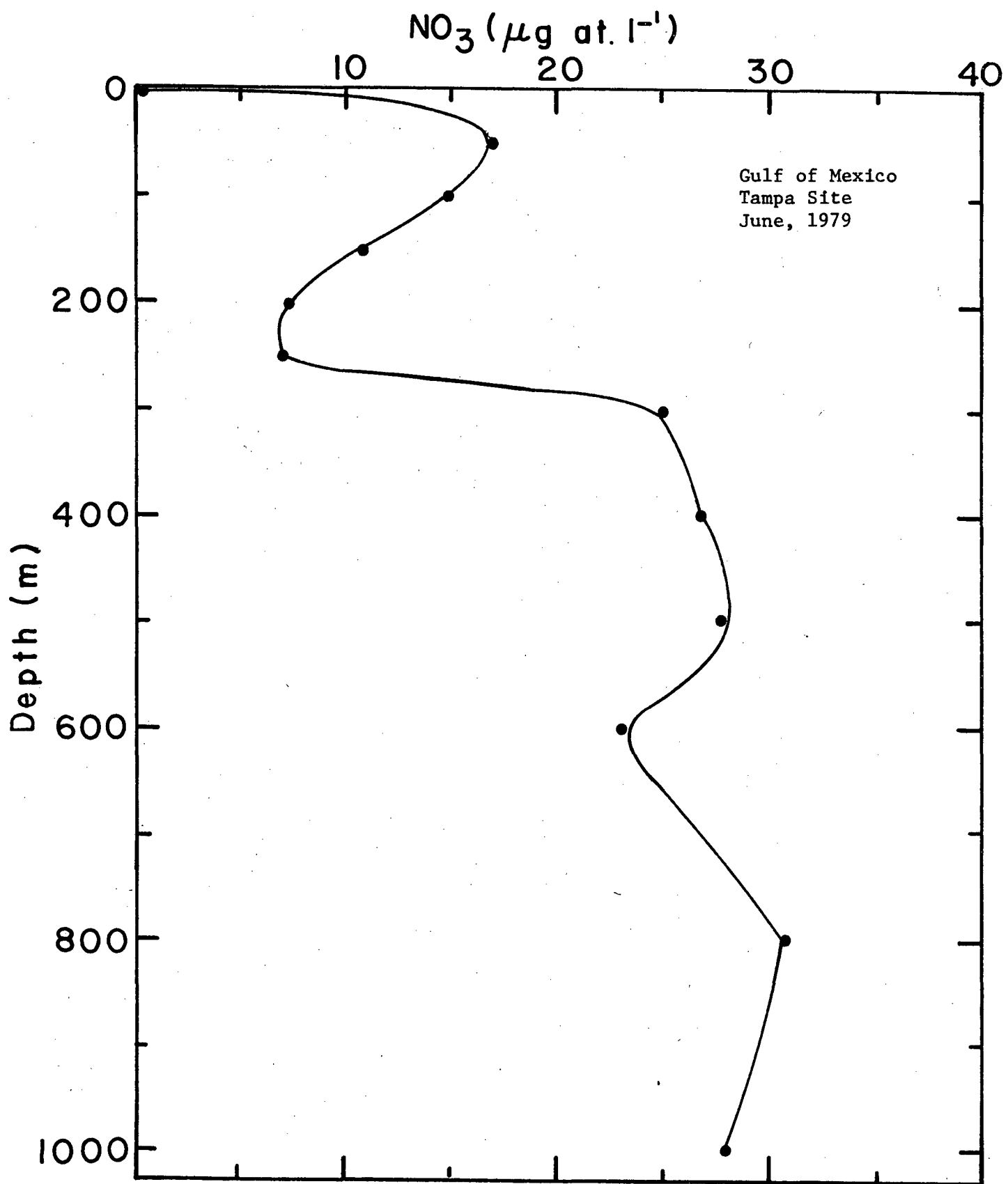
No Time given

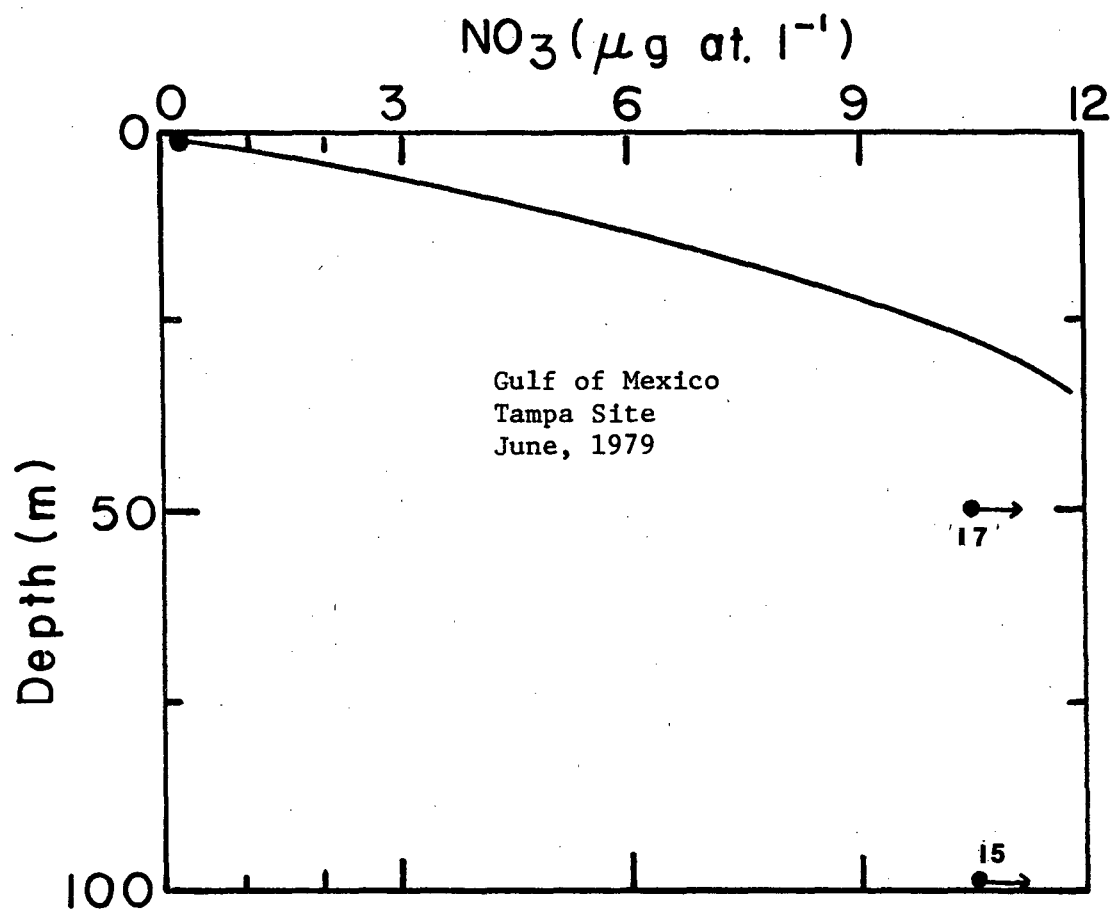
27° 39.33'N

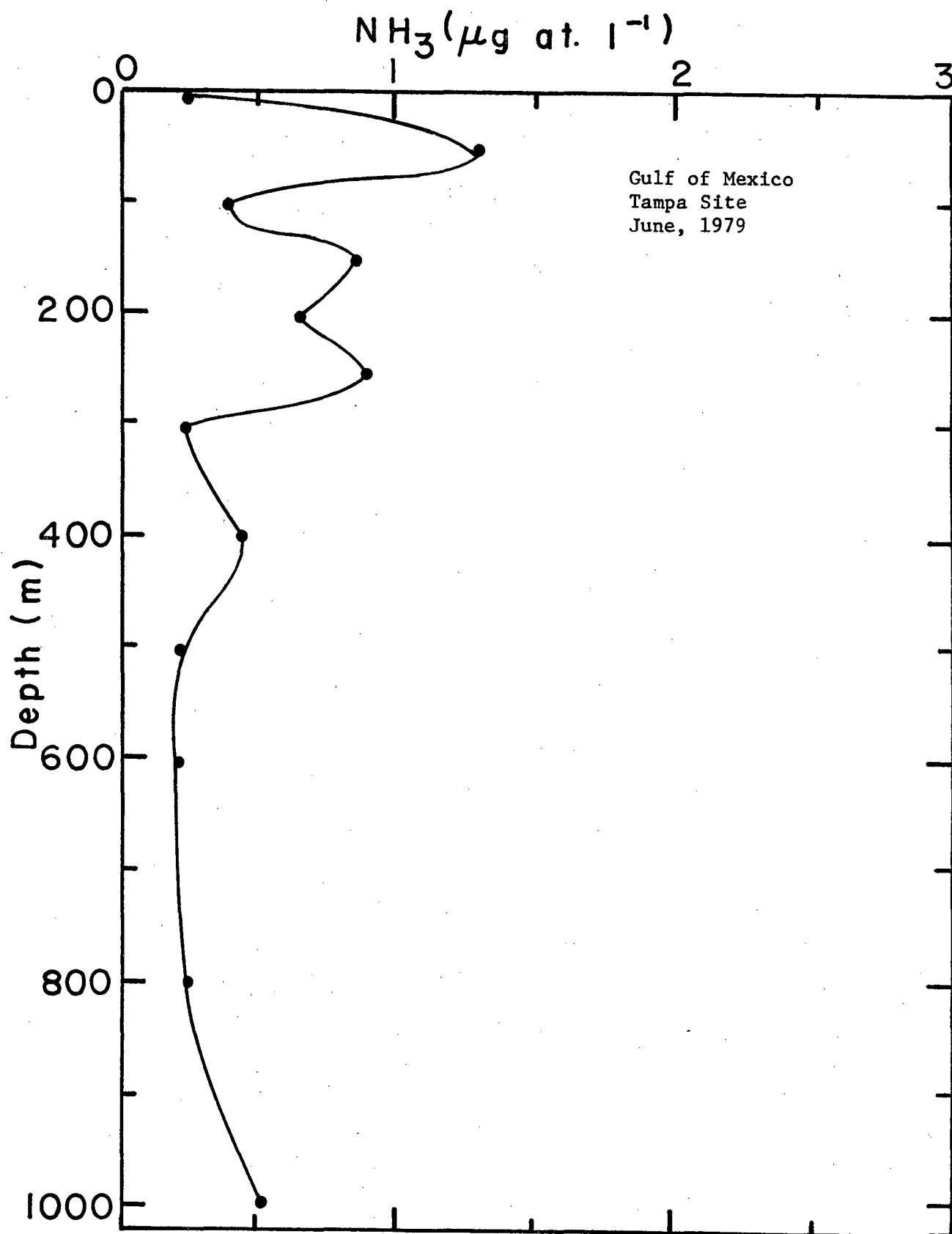
86° 32.81'W

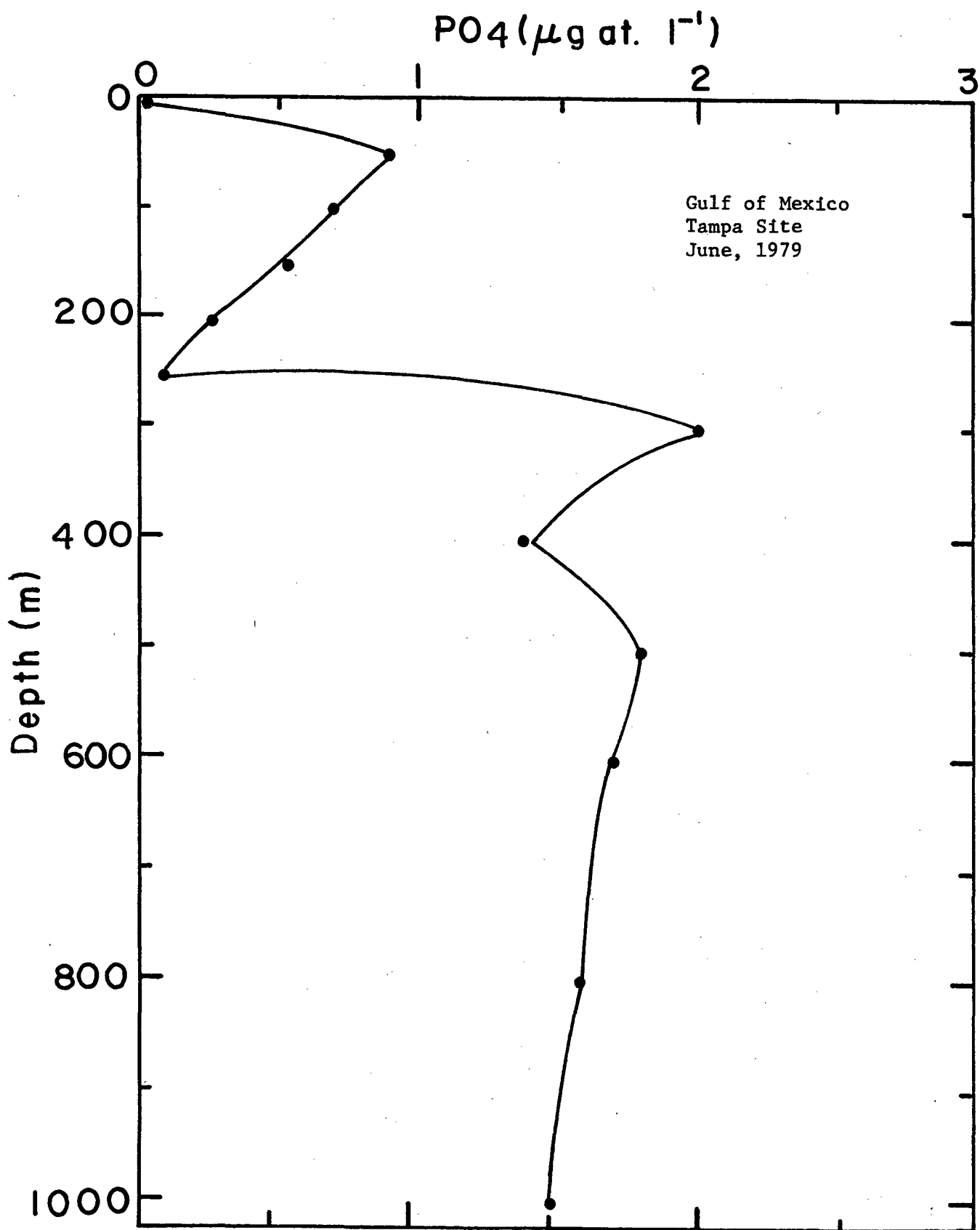
Depth (uncorrected m)	O ₂ (ml ℓ ⁻¹)	NO ₂ (μg at ℓ ⁻¹)	NO ₃ (μg at ℓ ⁻¹)	NH ₃ (μg at ℓ ⁻¹)	PO ₄ (μg at ℓ ⁻¹)	ΣPO ₄ (μg at ℓ ⁻¹)	SiO ₃ (μg at ℓ ⁻¹)
0	4.7	0	0.10	0.28	0.05	0.15	0
50	5.0	0	17	1.3	0.90	1.6	4.0
100	4.3	0	15	0.39	0.70	1.3	3.0
150	4.0	0	11	0.87	0.55	1.1	2.5
200	3.4	0	7.5	0.67	0.28	0.81	1.5
250	3.3	0	0.70	0.90	0.1	0.60	1.0
300	3.1	0	25	0.22	2.0	4.5	6.5
400	3.0	0	27	0.45	1.4	3.1	8.5
500	2.9	0	28	0.22	1.8	4.2	10
600	3.2	0	23	0.22	1.7	3.9	9.5
800	3.7	0	31	0.25	1.6	3.4	14
1000	4.2	0	28	0.56	1.5	3.2	15

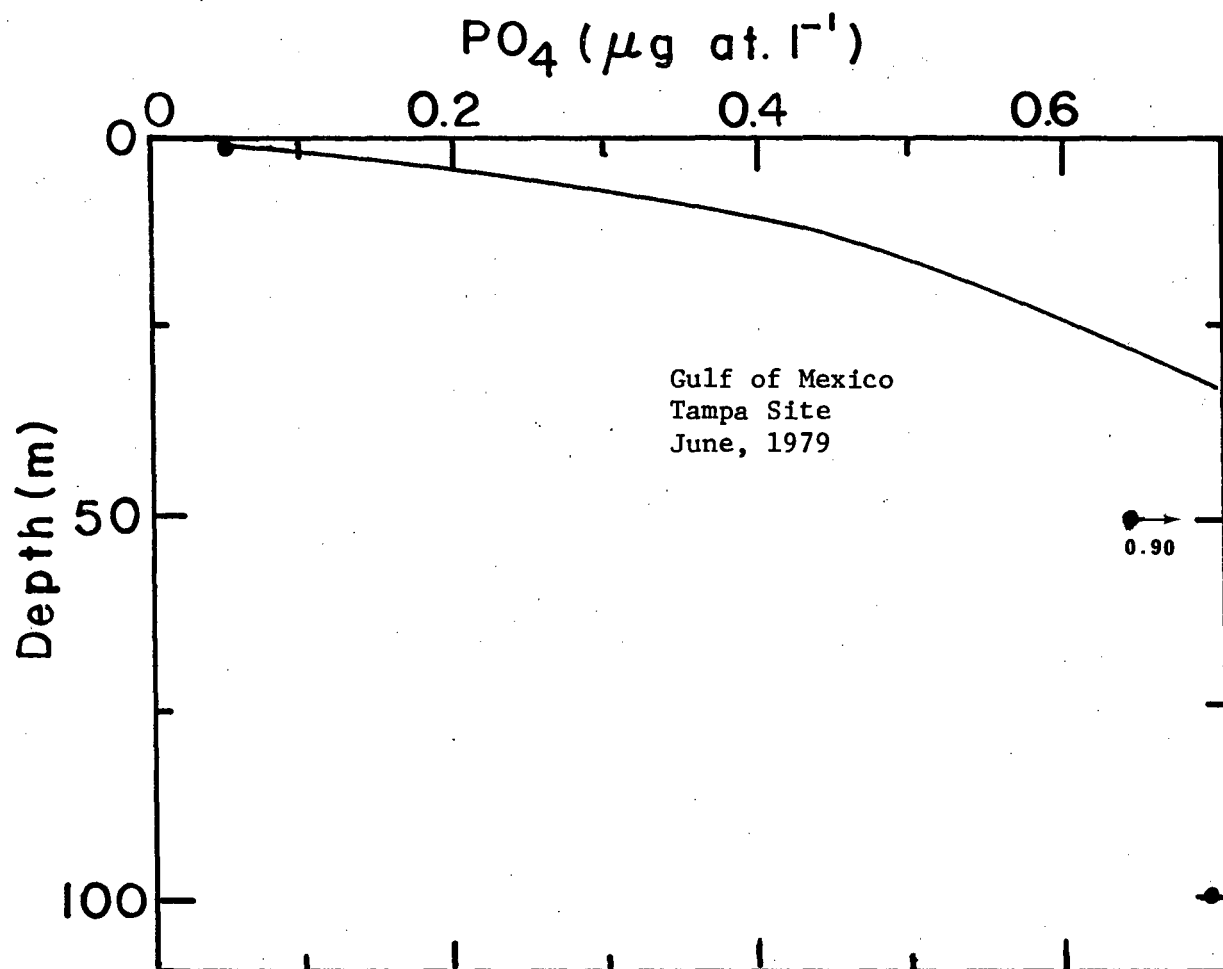


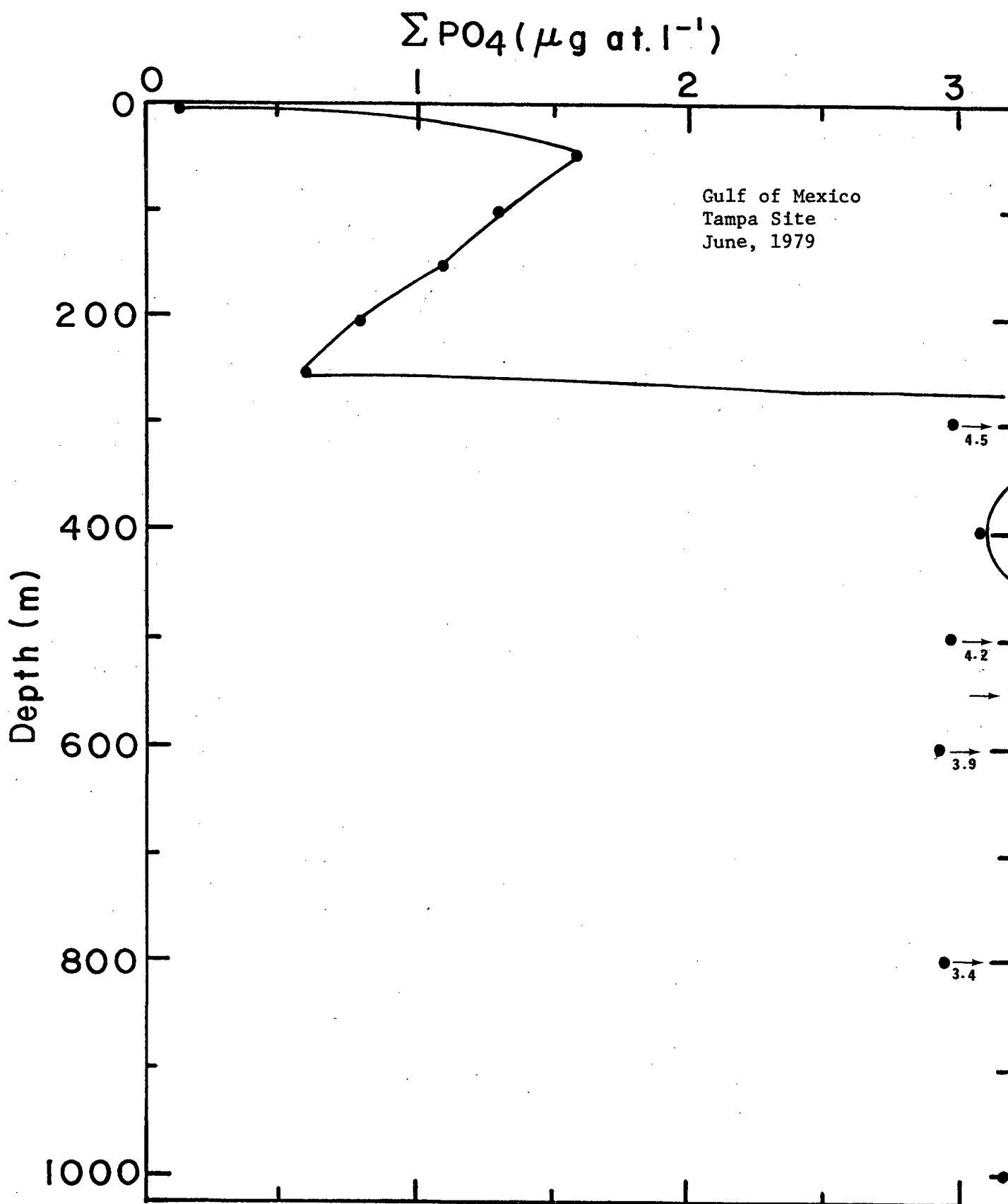


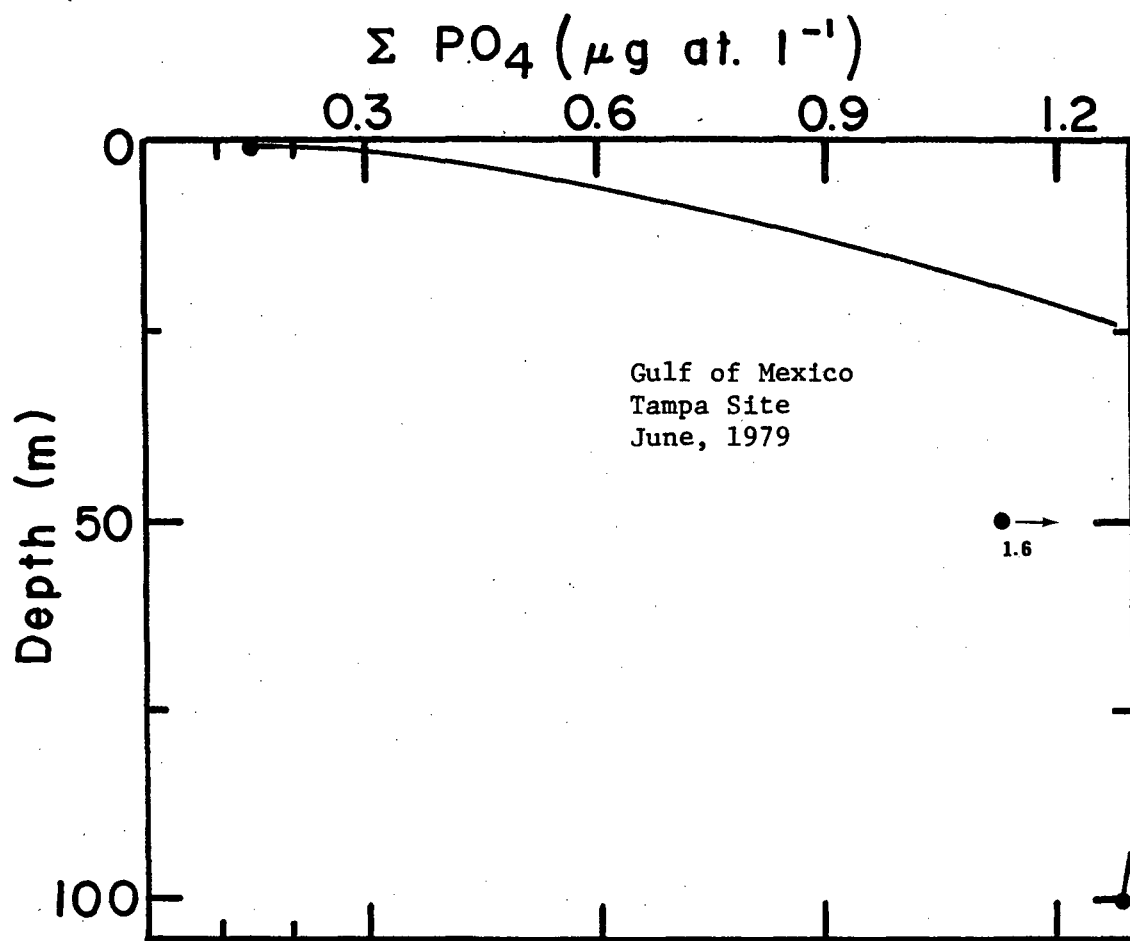


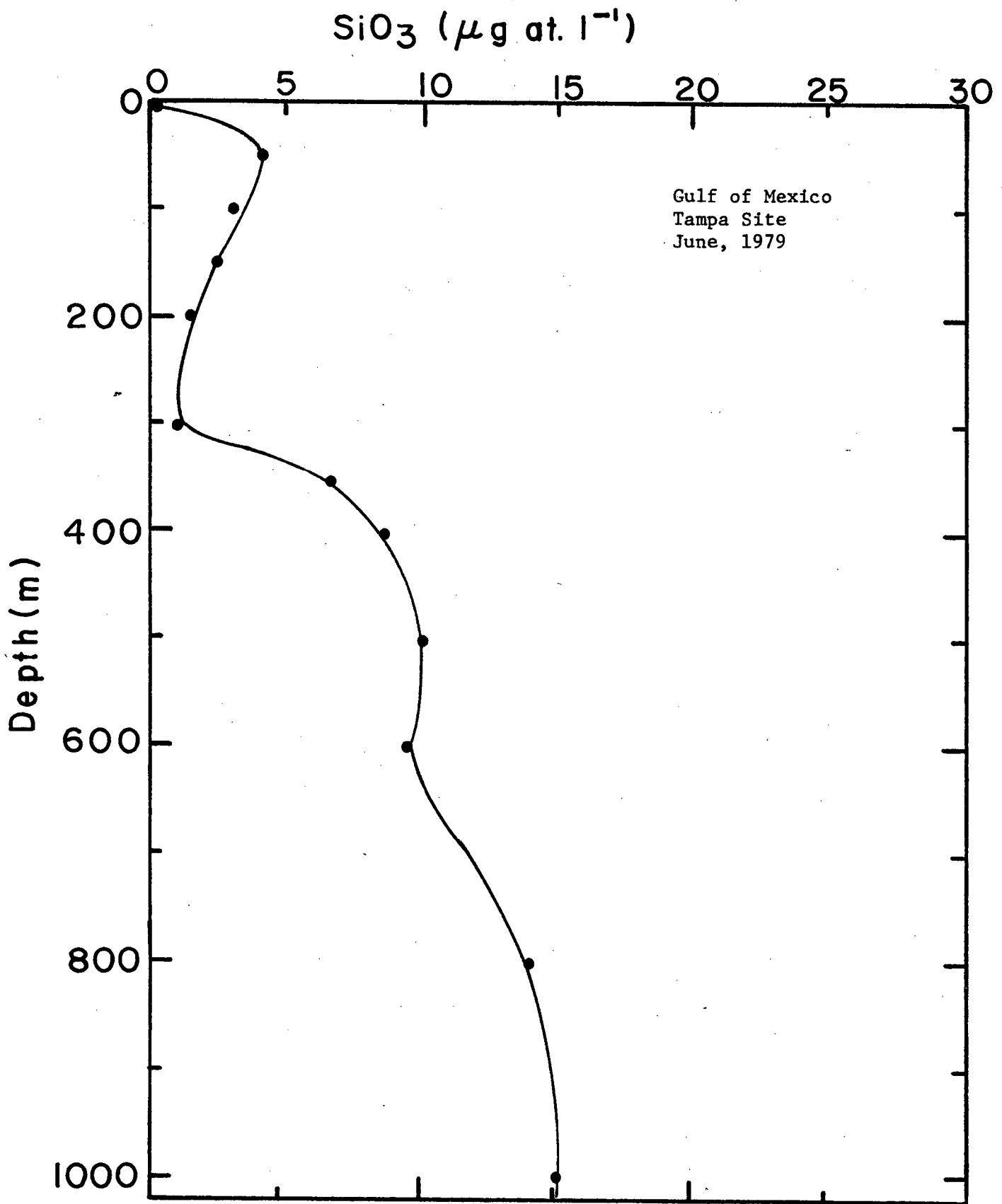


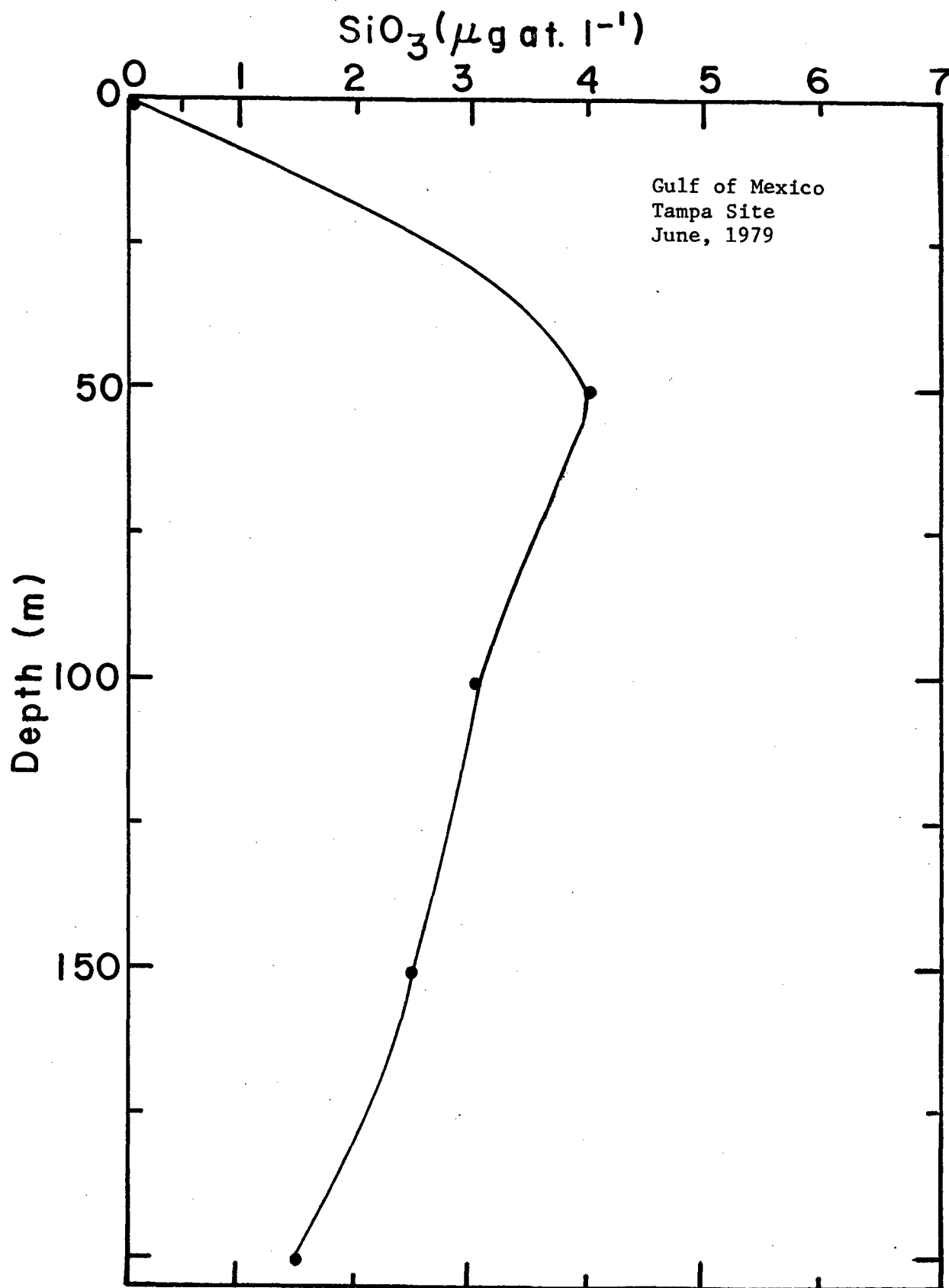






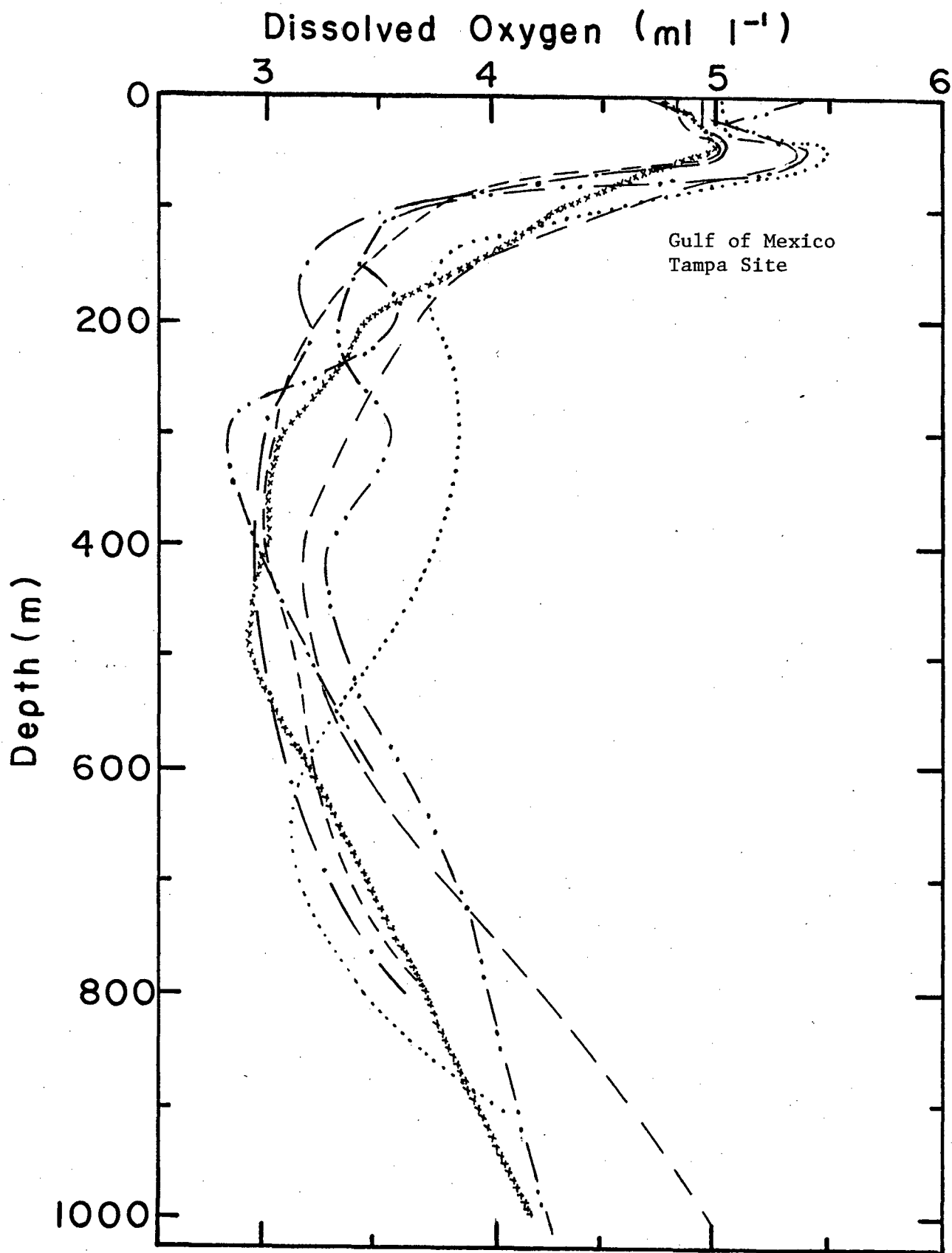


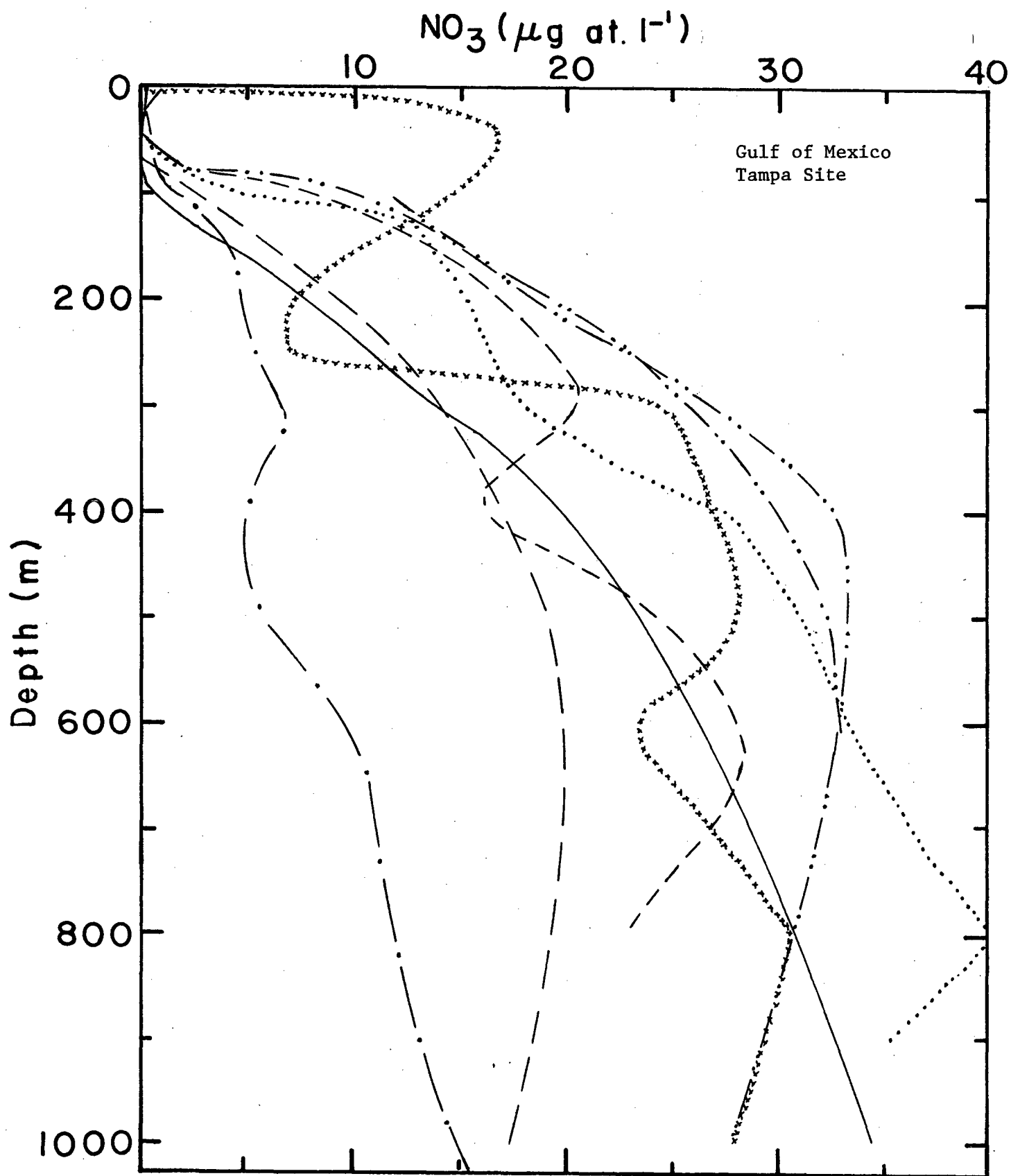


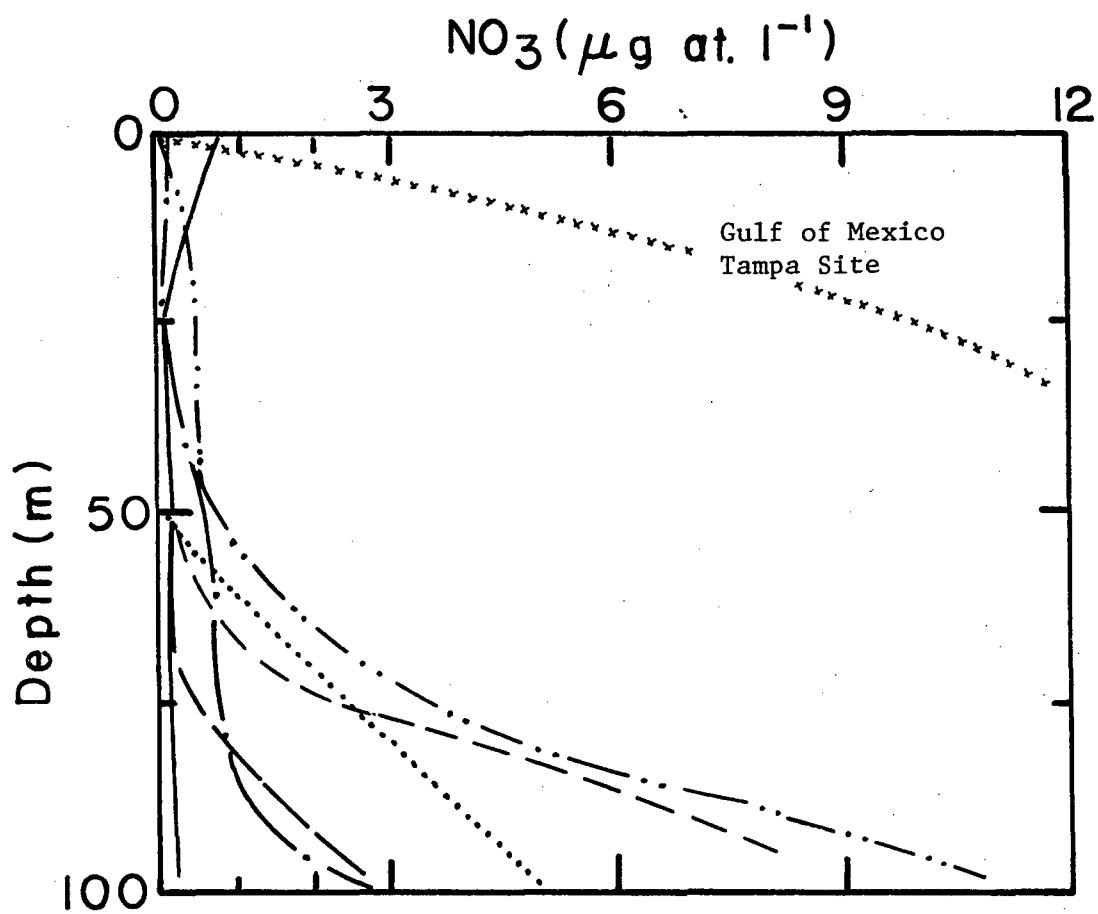


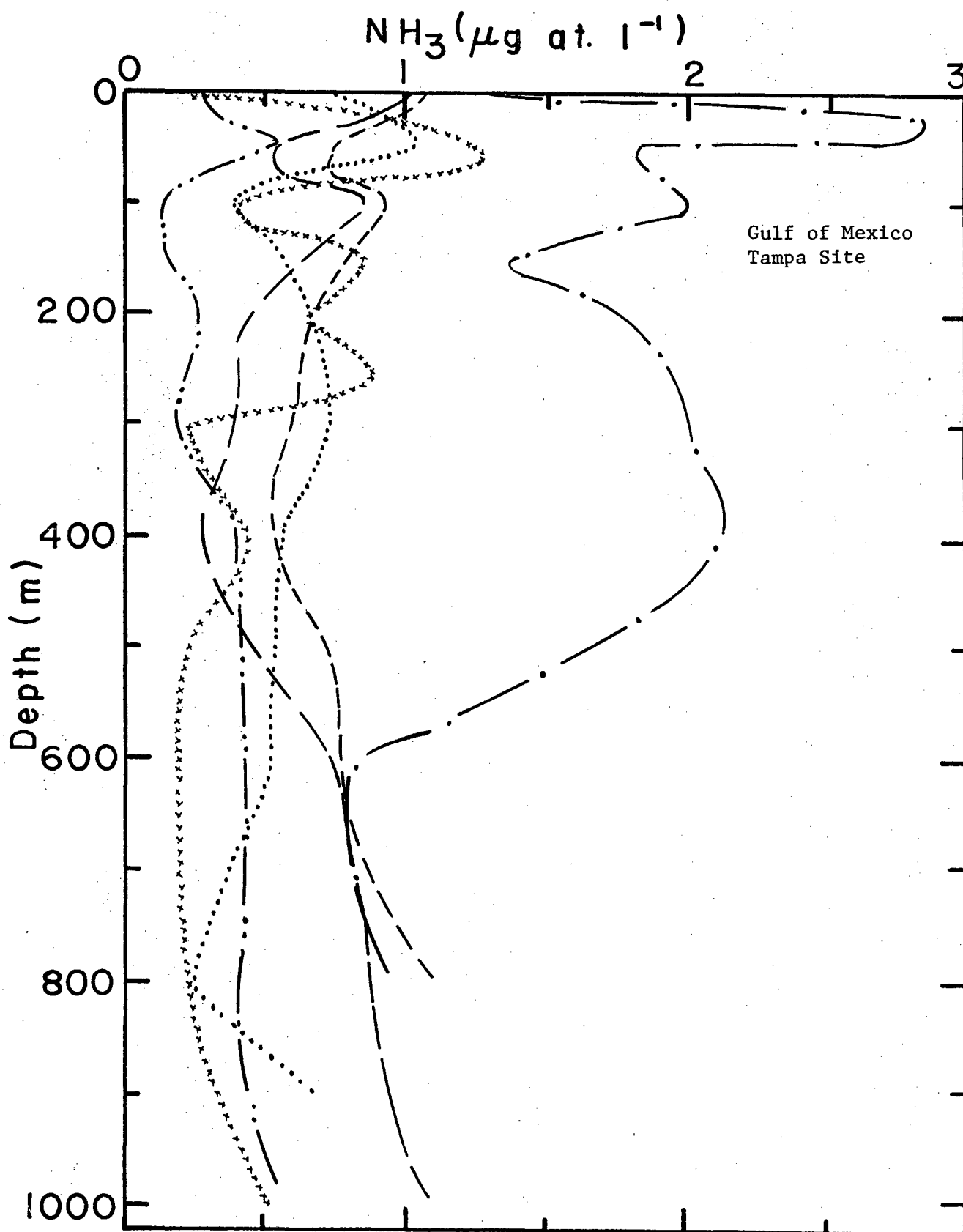
Tampa Site Composite Profiles

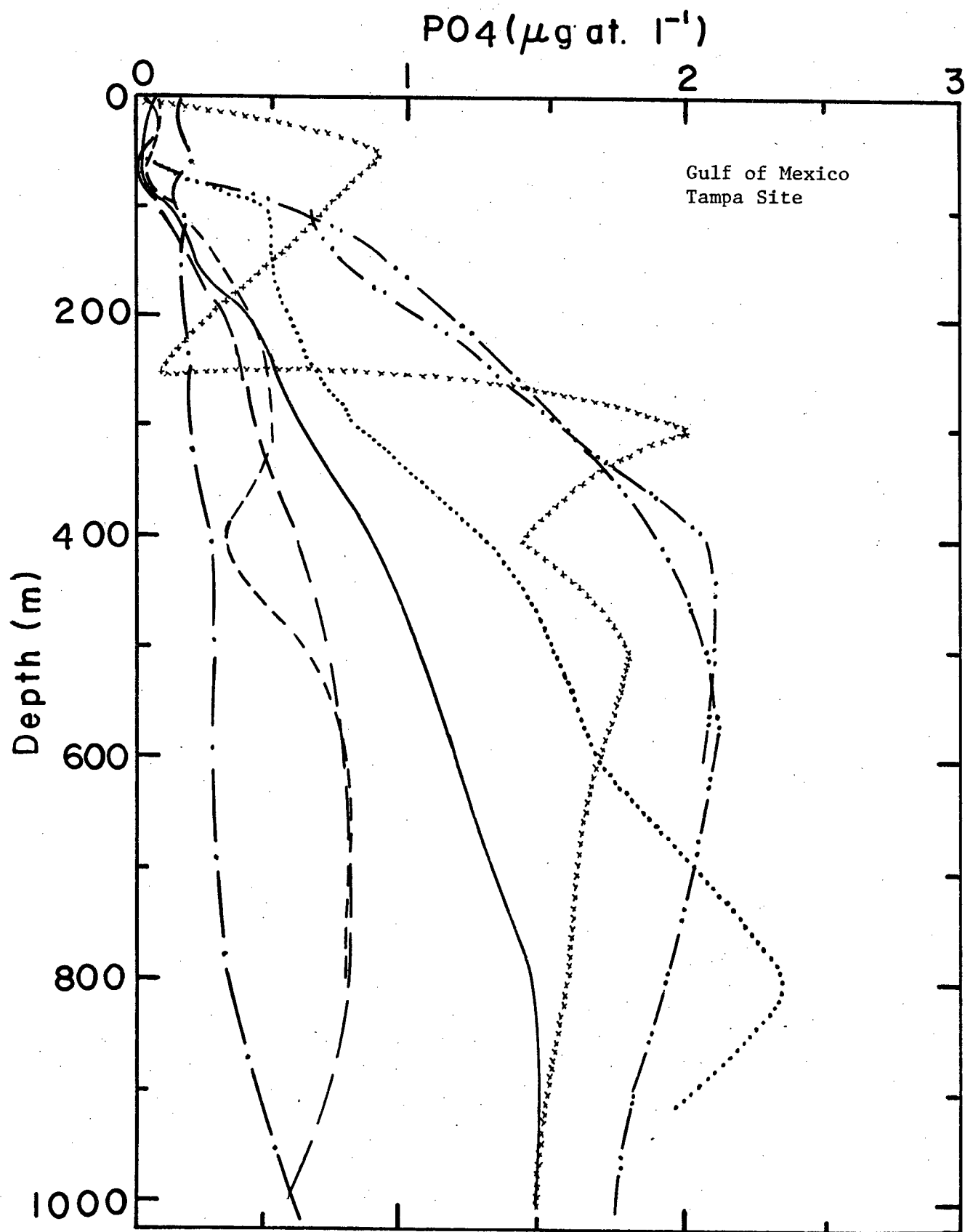
———— June, 1978
—— ——— August, 1978
- - - - - October, 1978
—— • ——— December, 1978
- • • ——— February, 1979
• • • • • April, 1979
xxxxxxx June, 1979

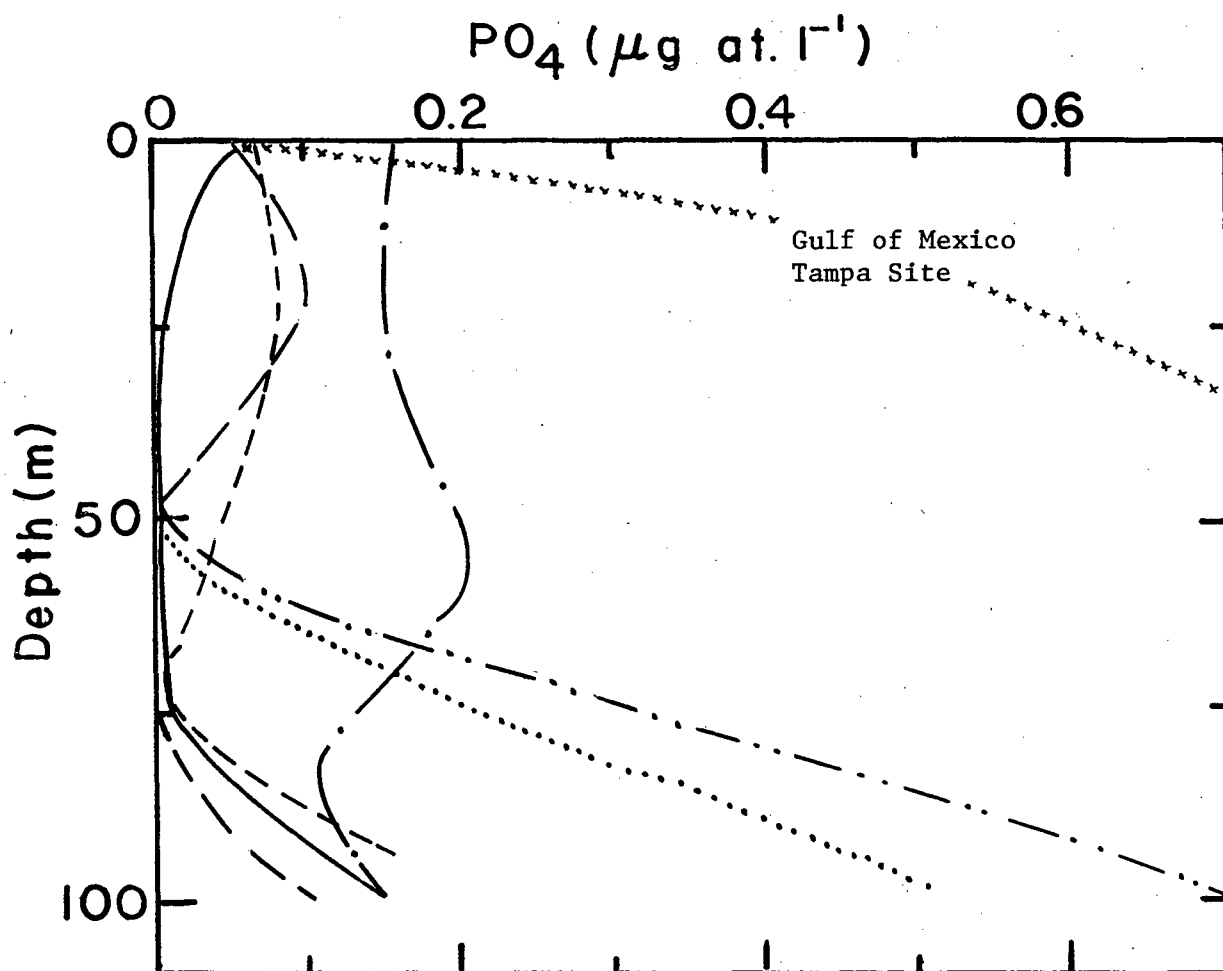


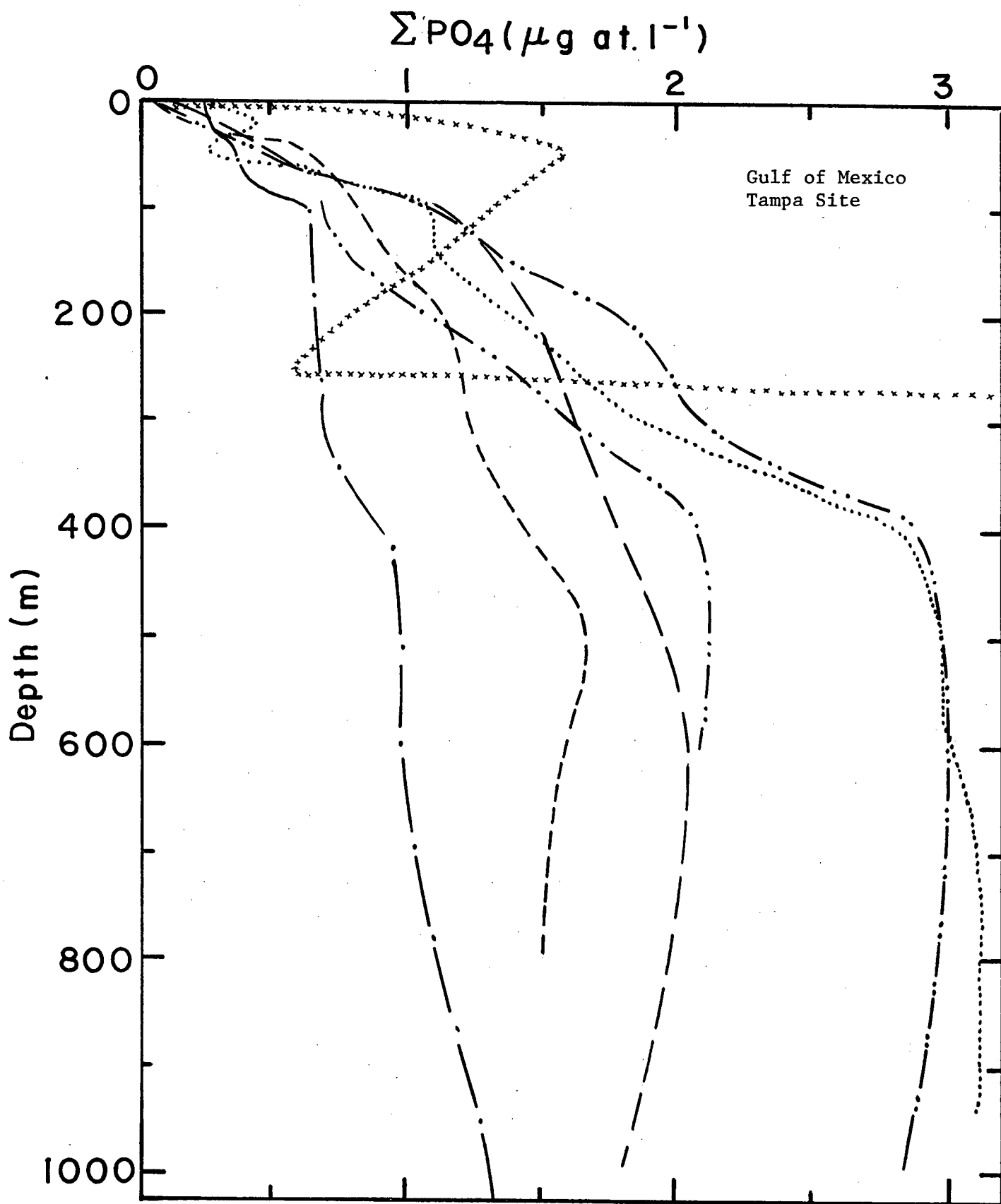


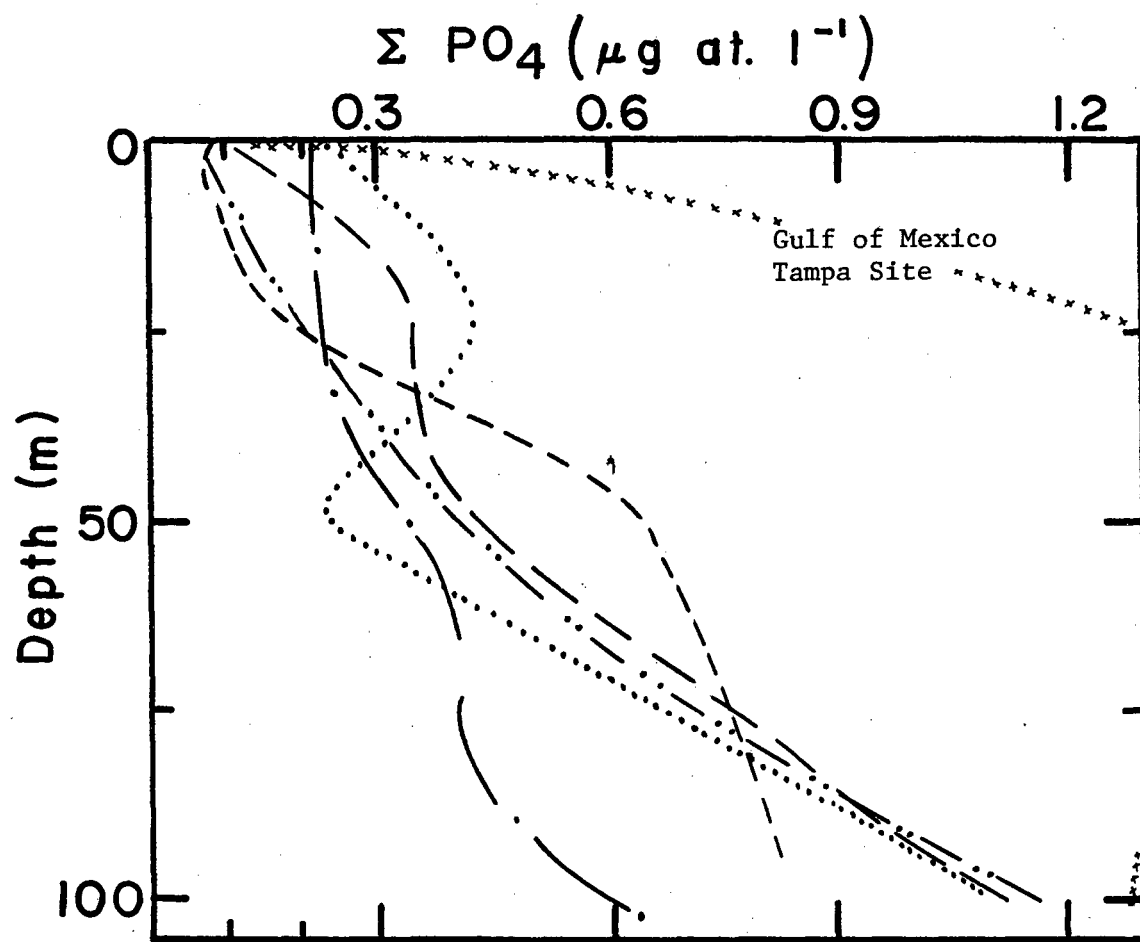


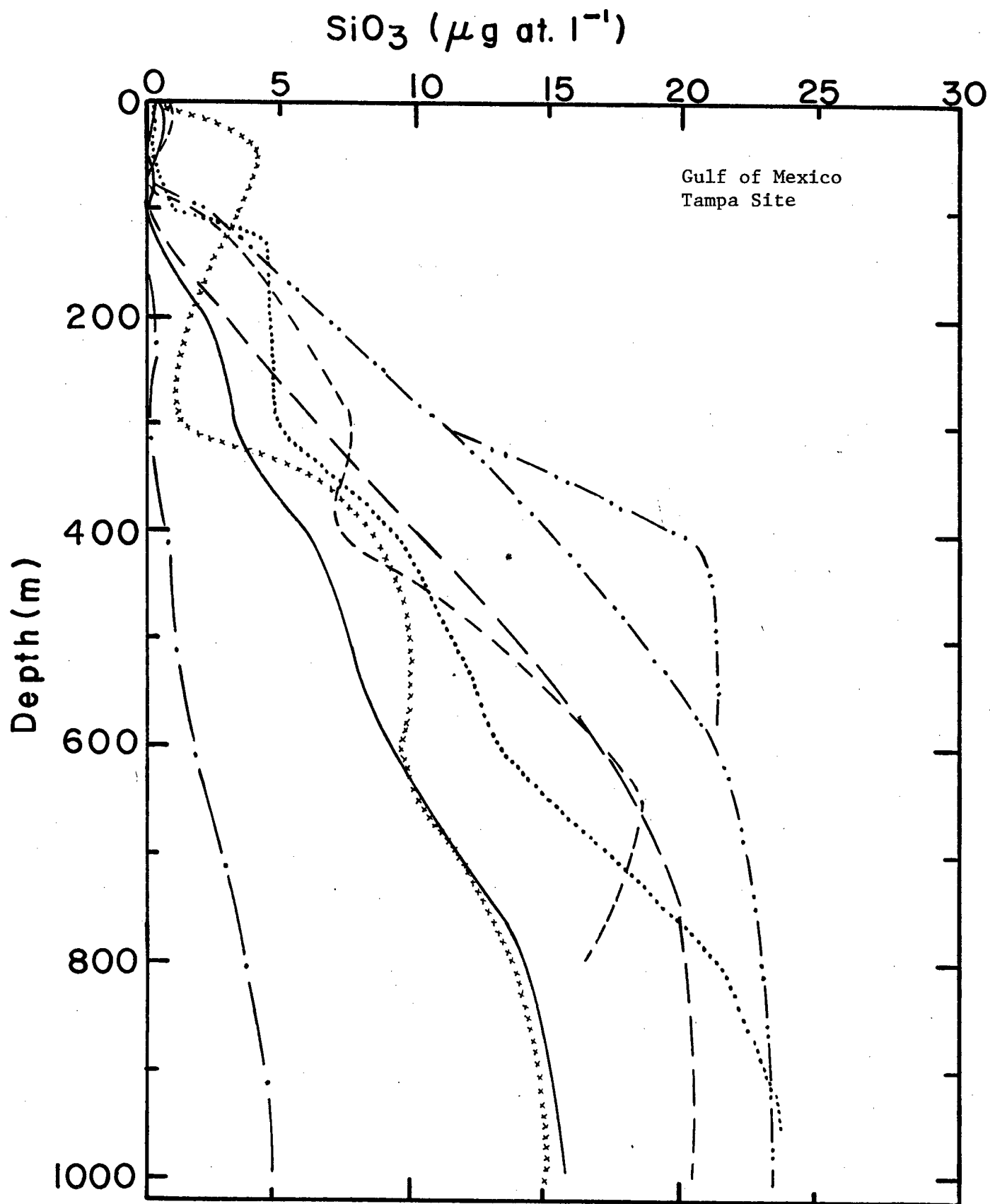


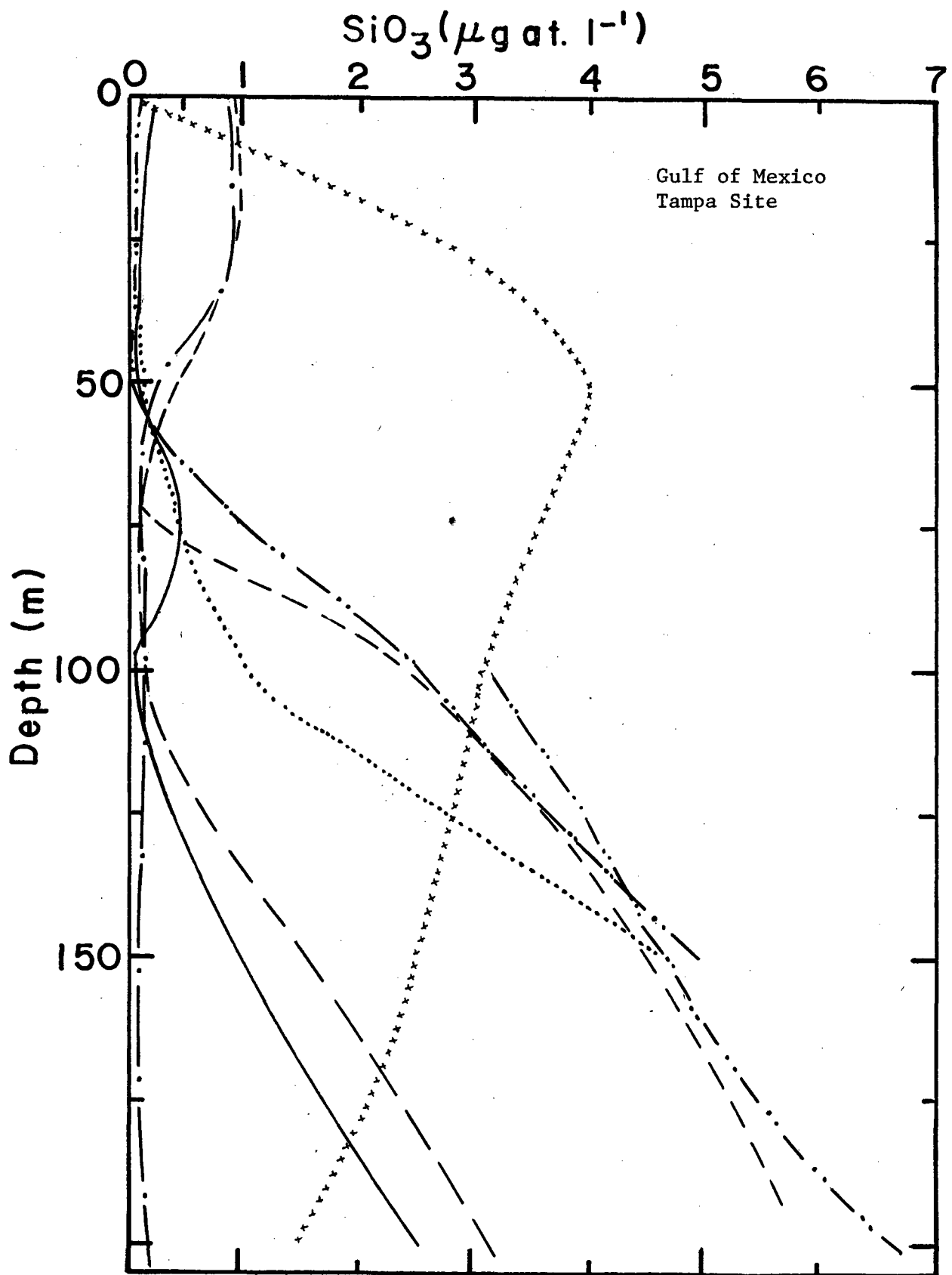












"REACTIVE" AND TOTAL PHOSPHATE COMPARISON

(Gulf of Mexico Tampa Site)

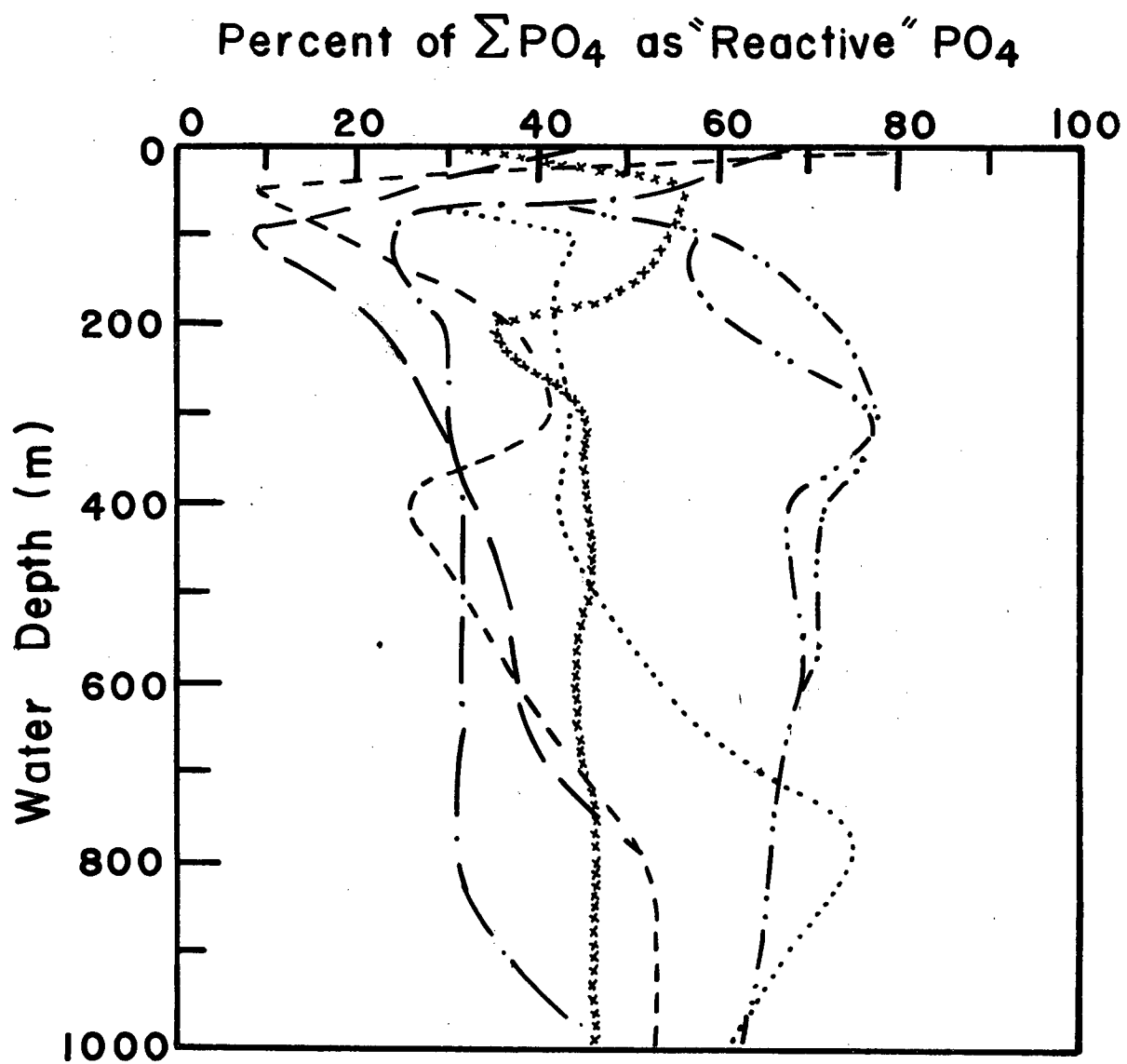
Percent of Total Phosphate Present as "Reactive" Phosphate

Depth (m, approx.)	June 1978	August 1978	October 1978	December 1978	February 1979	April 1979	June 1979
0	ND	45	78	68	*	*	33
25	ND	30	44	63	*	*	-
50	ND	*	9	56	*	*	56
75	ND	*	*	25	43	30	-
100	ND	9	18	24	61 (58)	44	54
150	ND	15	32	25	68 (57)	41	50
200	ND	24	36	29	29** (61)	ND	35
300	ND	28	41	30	77 (77)	43	44
400	ND	33	25	32	66 (72)	42	45
600	ND	37	38	31	70 (70)	53	44
800	ND	41	52	32	65	75	47
900- 1000	ND	33	53	46	63	61	47

* Reactive PO_4 below detection limit

** Improperly preserved sample

Note: 2 stations in February



"REACTIVE" PHOSPHATE TO NITRATE COMPARISON

(Gulf of Mexico Tampa Site)

Depth (m, approx.)	Reactive PO ₄ : NO ₃ Ratio						
	June 1978	August 1978	October 1978	December 1978	February 1979	April 1979	June 1979
0	0.05	0.50	1.4	0.60	*	*	0.50
25	*	*	1.6	0.60	*	*	-
50	*	*	1.0	0.27	*	*	0.05
75	*	*	*	0.11	0.07	0.08	-
100	0.79	0.04	0.02	0.05	0.10 (0.06)	0.10	0.05
150	0.04	0.03	0.02	0.03	0.06 (0.05)	0.04	0.05
200	0.06	0.04	0.02	0.04	0.06** (0.06)	ND	0.04
300	0.04	0.03	0.02	0.03	0.07 (0.06)	0.05	0.08
400	0.04	0.04	0.03	0.07	0.06 (0.06)	0.05	0.05
600	0.05	0.04	0.03	0.03	0.04 (0.06)	0.05	0.07
800	0.05	0.04	0.03	0.03	0.04	0.06	0.05
900- 1000	0.04	0.04	0.03	0.04	0.06	0.06	0.05

* Reactive phosphate and/or nitrate below detection limit

** Improperly preserved sample

Note: 2 stations in February

GULF OF MEXICO - MOBILE SITE

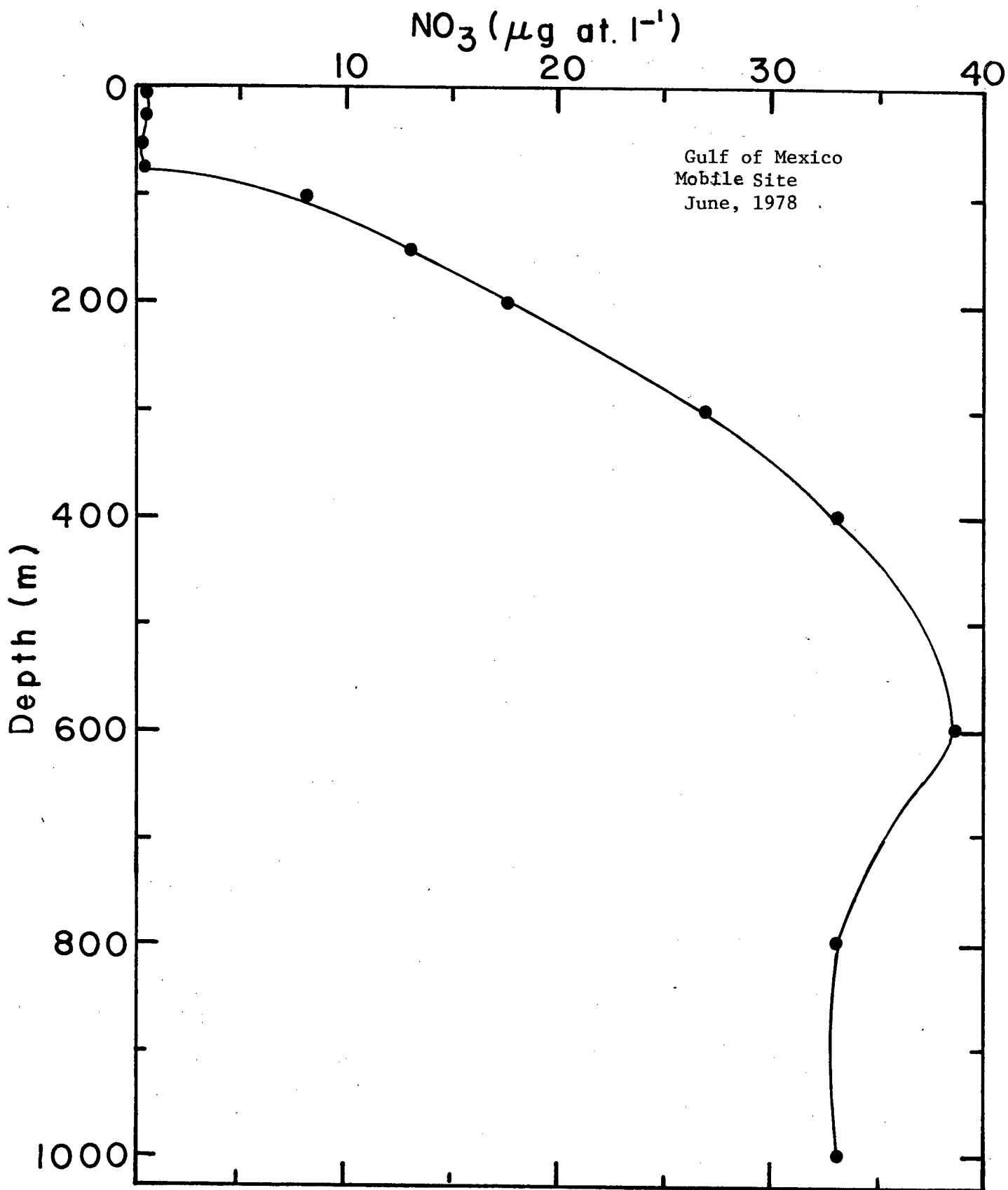
STATION, TIME AND POSITION UNCERTAIN (June, 1978)

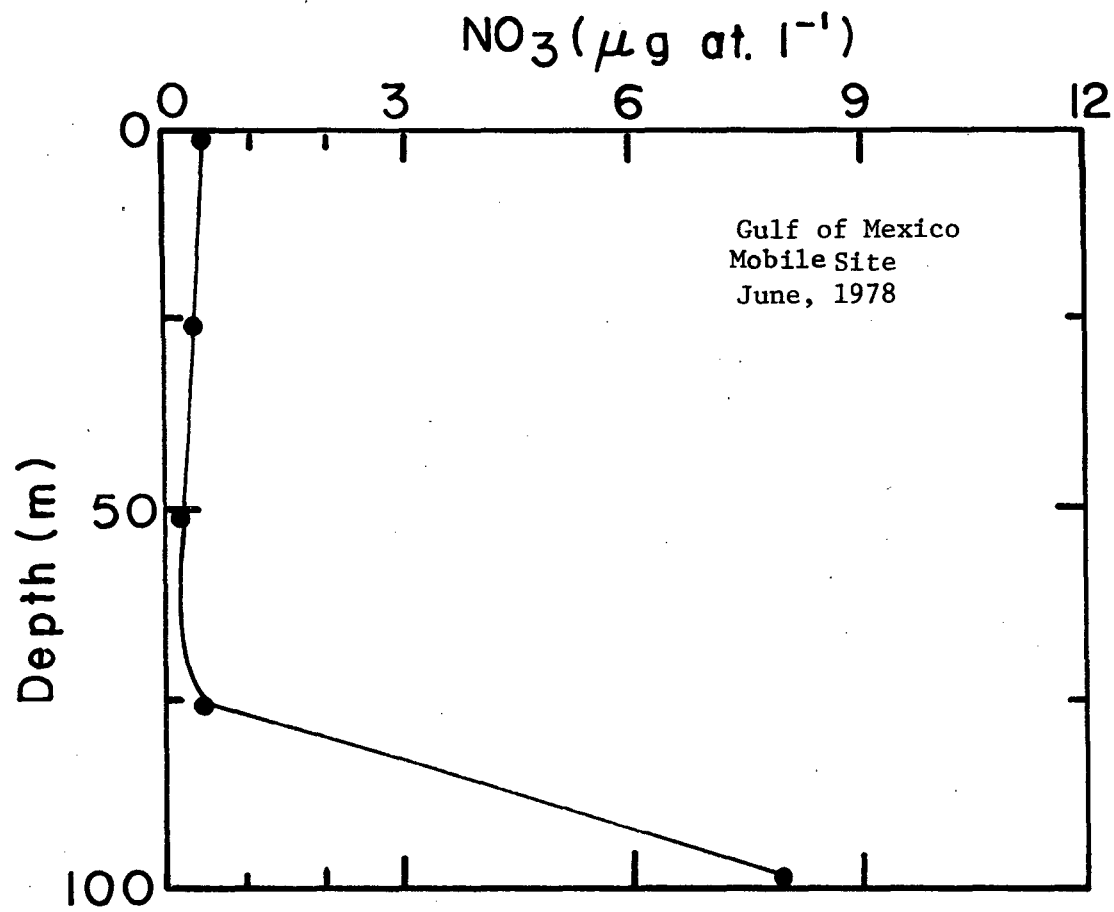
Depths Estimated

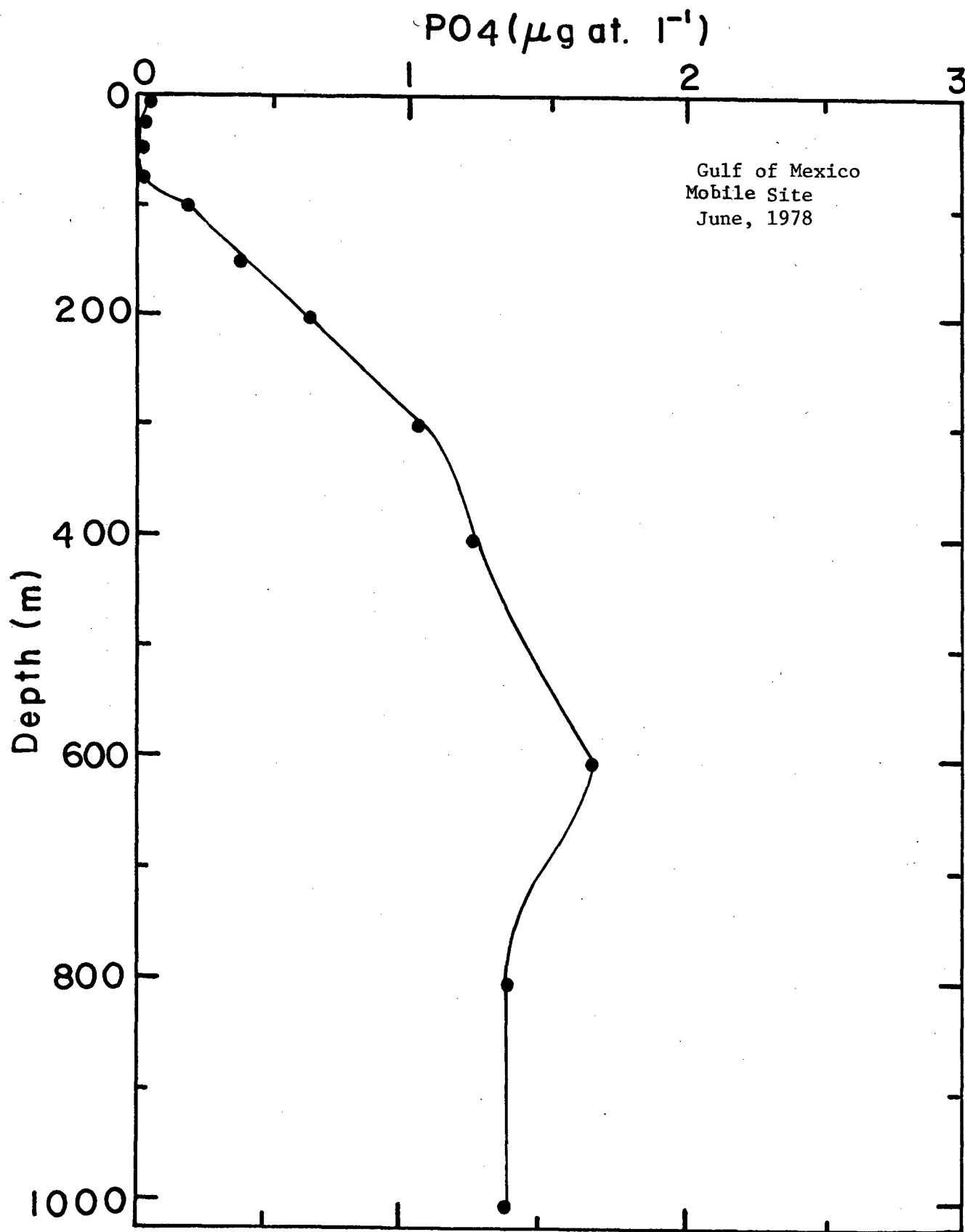
Depth (uncorrected m)	O ₂ * (ml l ⁻¹)	NO ₂ (μg at l ⁻¹)	NO ₃ (μg at l ⁻¹)	NH ₃ * (μg at l ⁻¹)	PO ₄ ** (μg at l ⁻¹)	ΣPO ₄ (μg at l ⁻¹)	SiO ₃ (μg at l ⁻¹)
0	-	0	0.50	-	0.05	-	0.50
25	-	0	0.40	-	0	-	0
50	-	0	0.15	-	0	-	0
75	-	0.05	0.43	-	0	-	0
100	-	0.05	8.0	-	0.20	-	1.0
150	-	0.10	13	-	0.40	-	2.5
200	-	0.08	17	-	0.65	-	3.5
300	-	0.08	27	-	1.1	-	6.5
400	-	0.09	33	-	1.3	-	9.5
600	-	0.10	39	-	1.7	-	14
800	-	0.10	33	-	1.4	-	17
1000	-	0.10	33	-	1.4	-	17

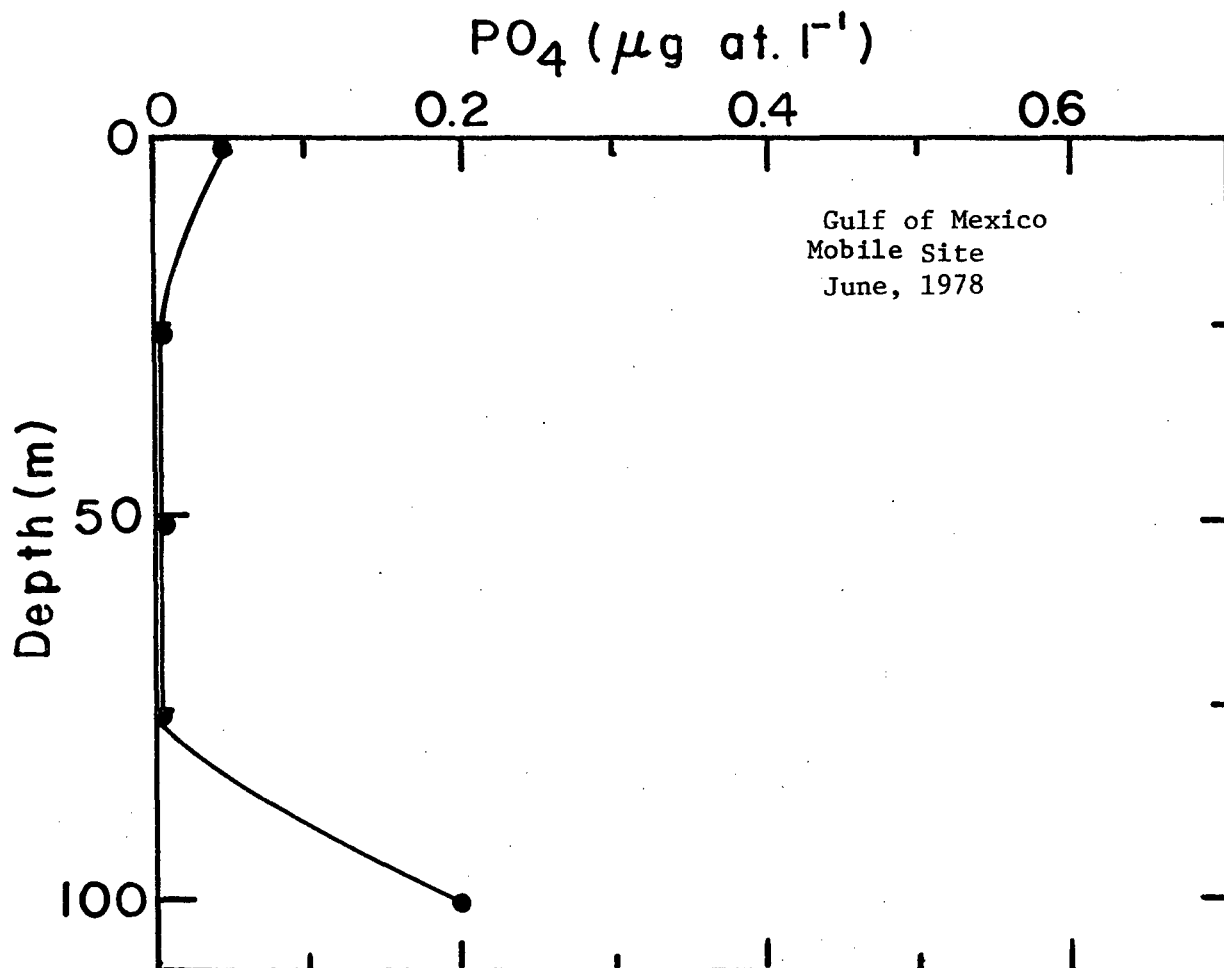
* Not reported due to improper sample preservation

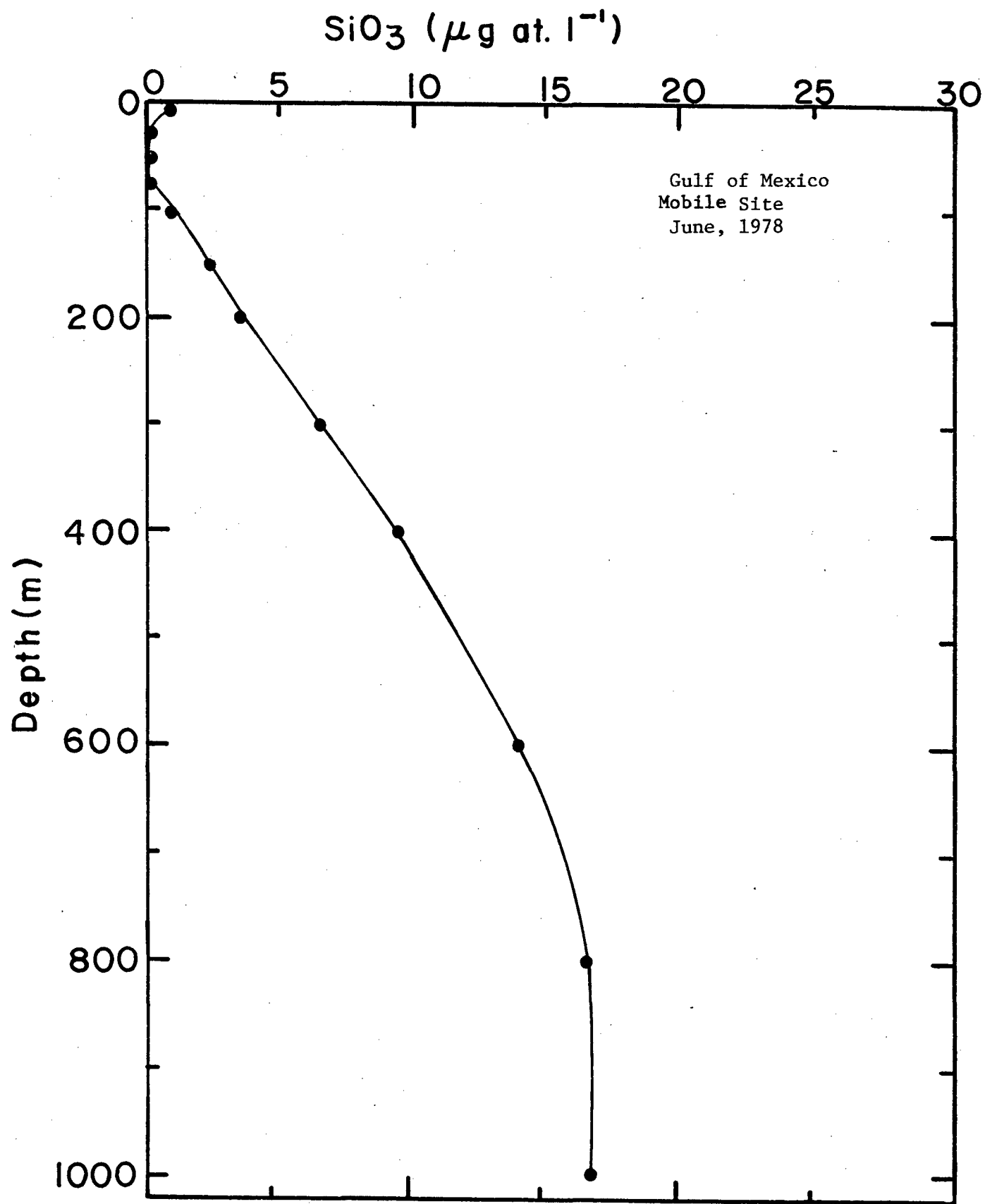
** Not determined

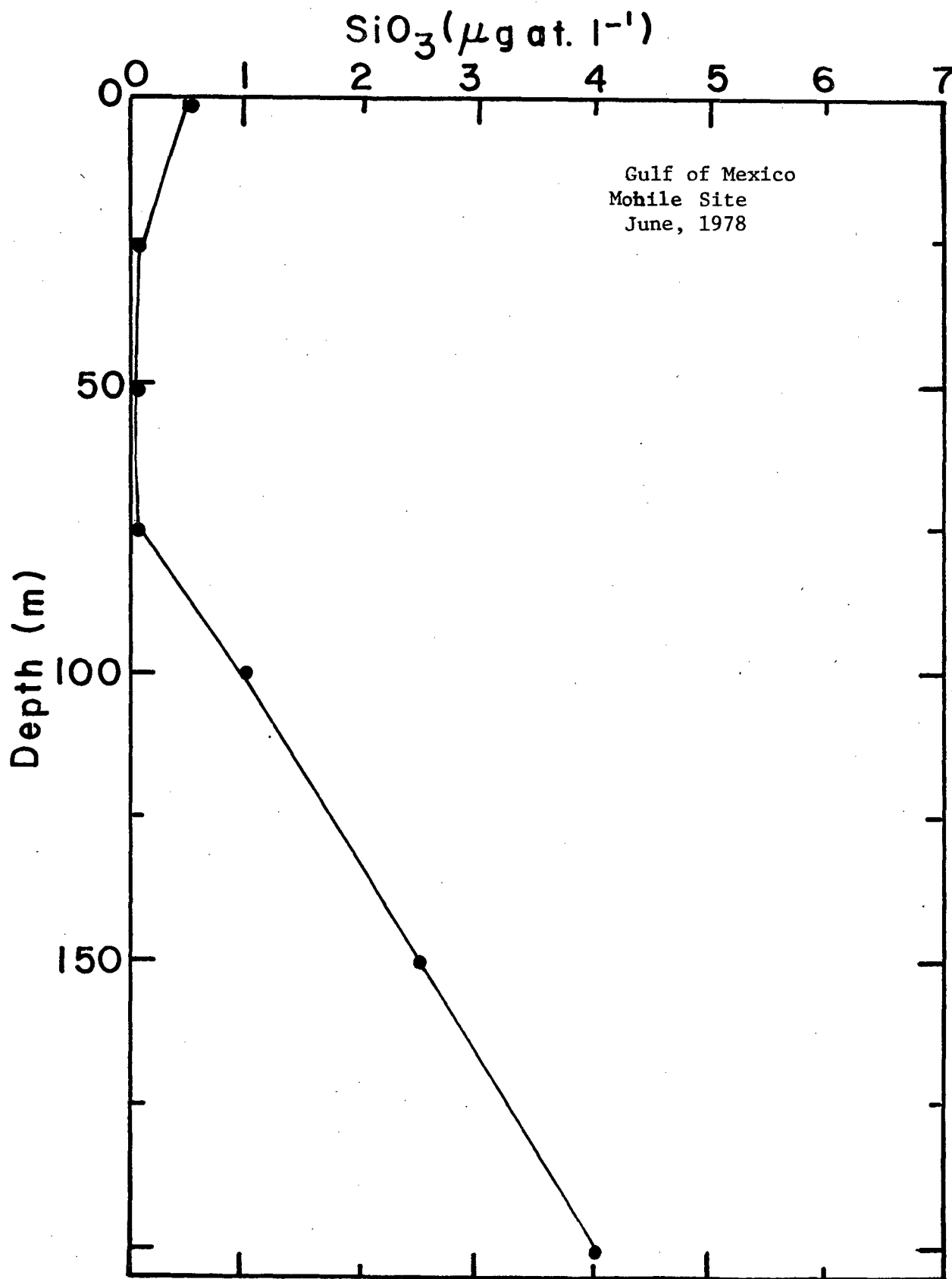








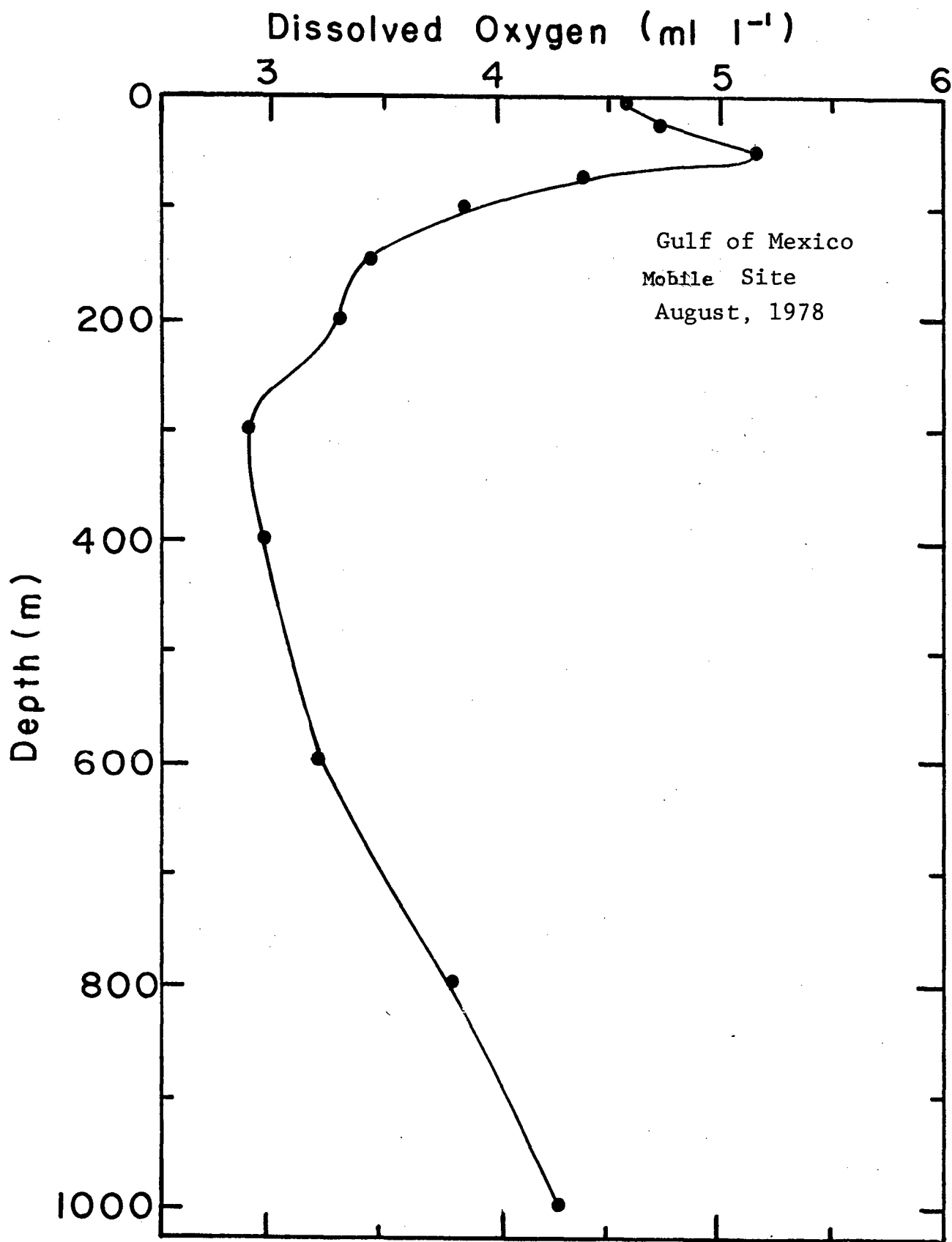


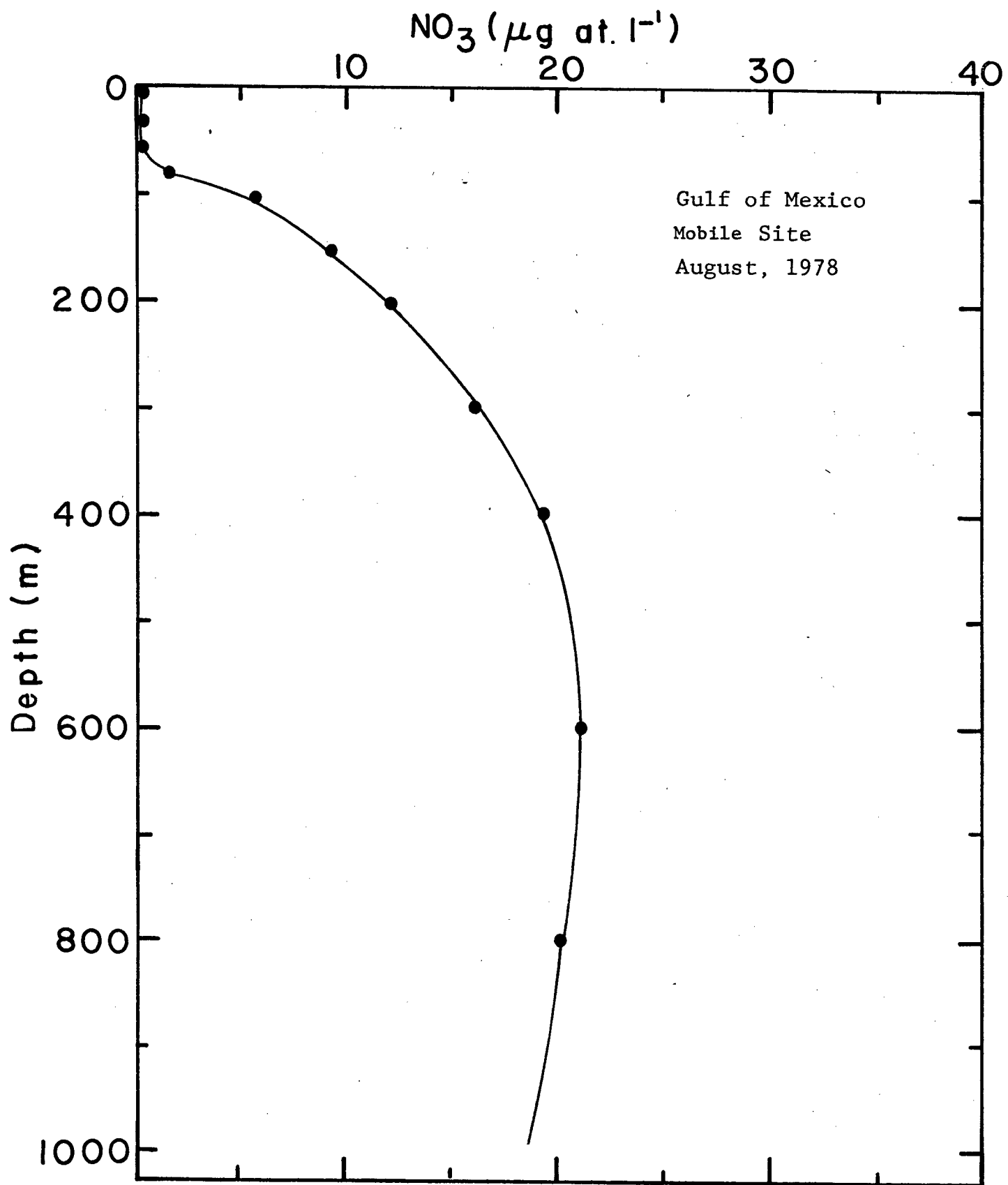


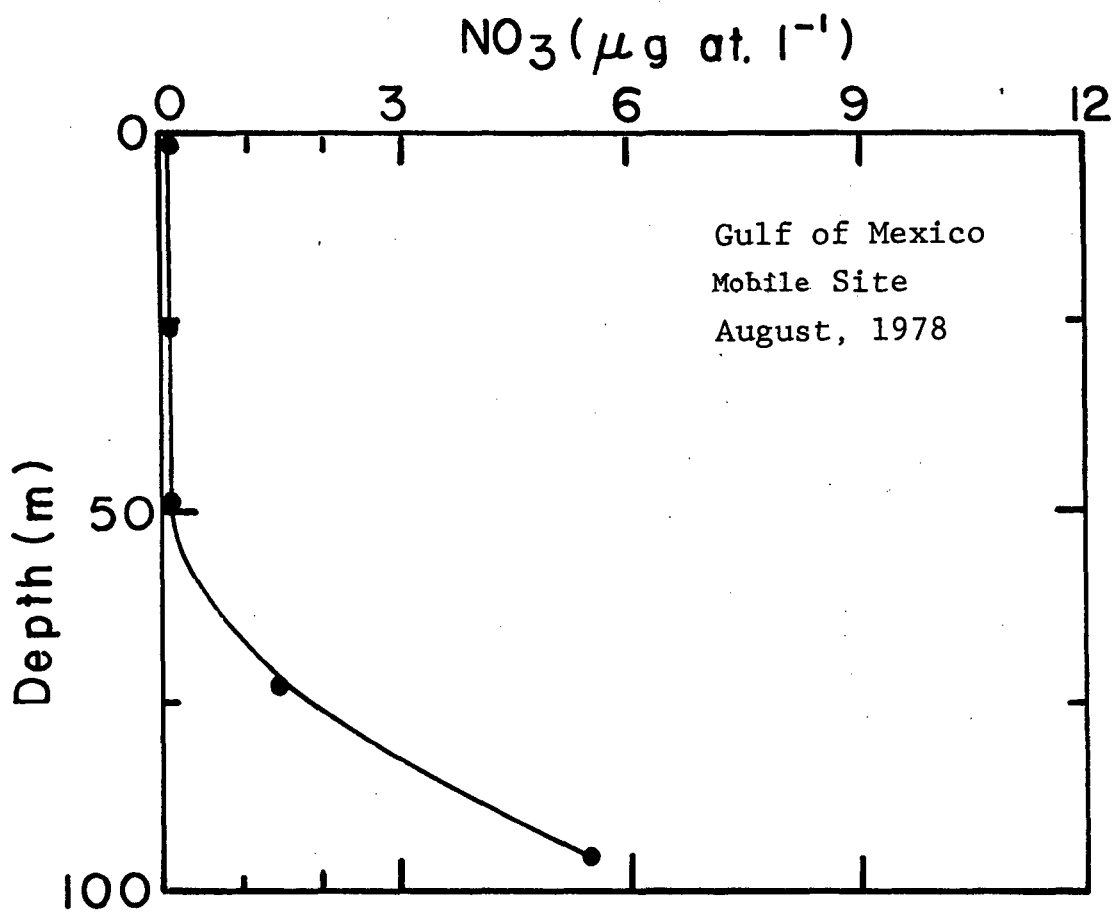
GULF OF MEXICO - MOBILE SITE

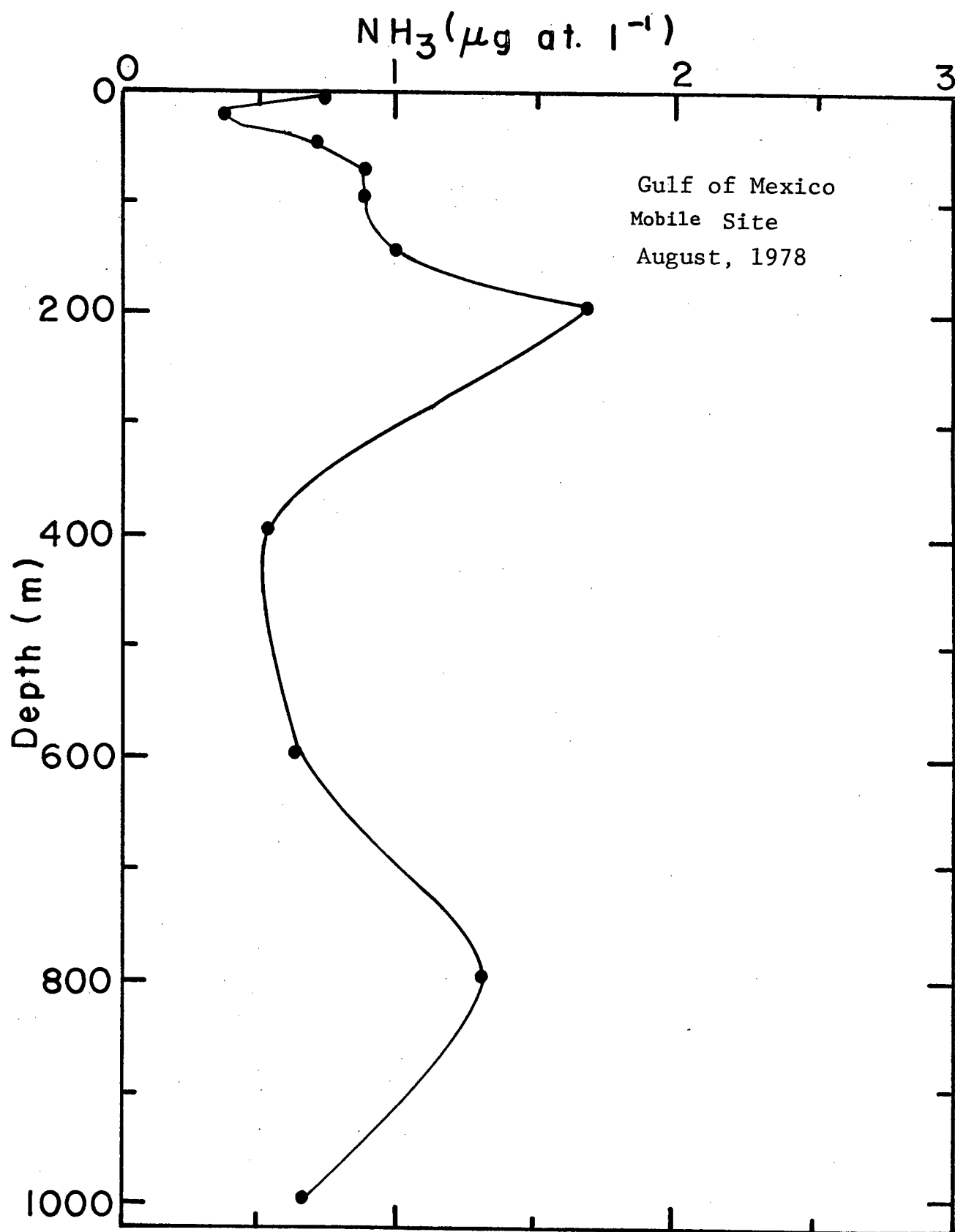
STATION 8 8/22/78 0110 Z 29° 11'N 87° 38'W

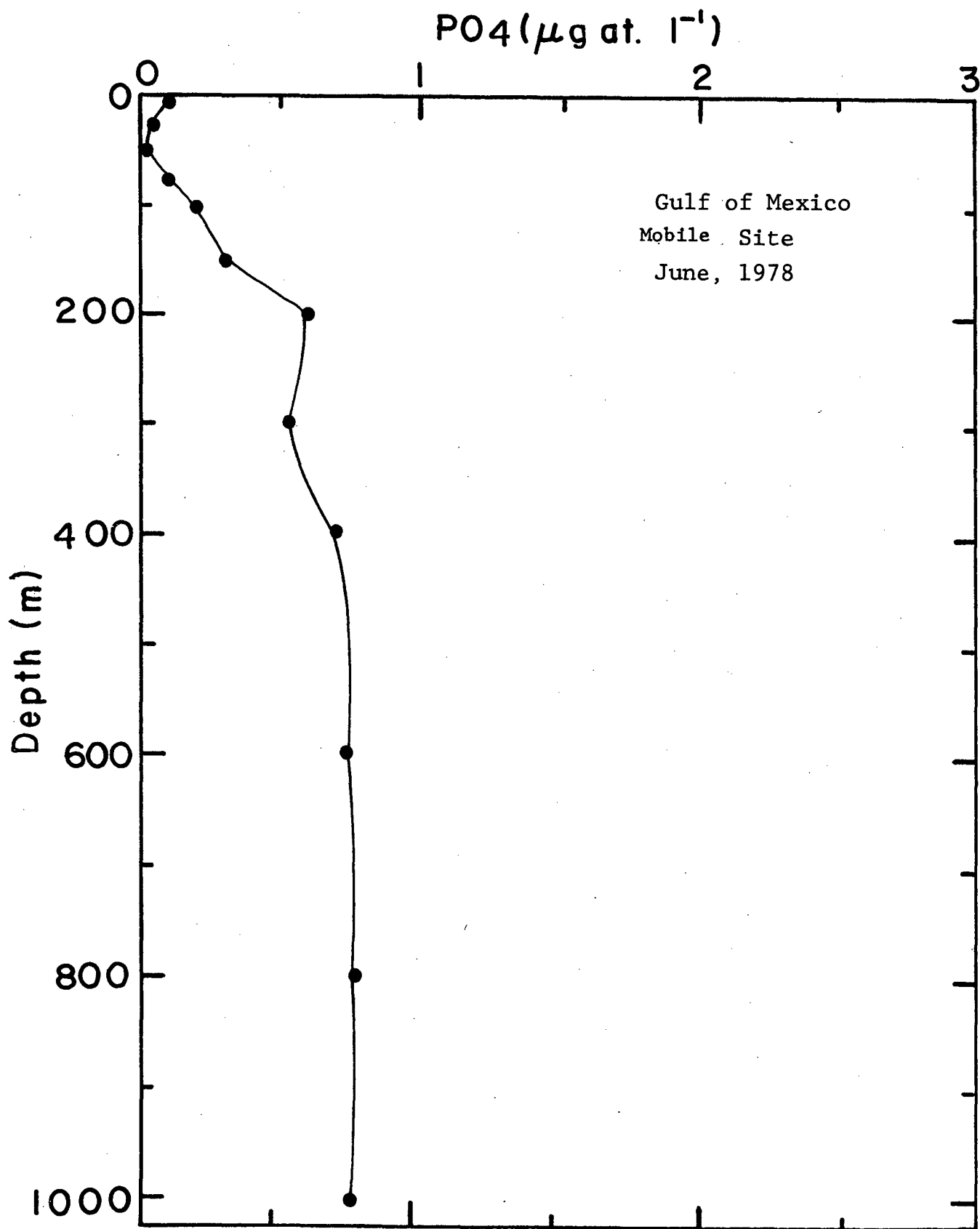
Depth (Corrected m)	O_2 (ml ℓ^{-1})	NO_2 (μg at ℓ^{-1})	NO_3 (μg at ℓ^{-1})	NH_3 (μg at ℓ^{-1})	PO_4 (μg at ℓ^{-1})	ΣPO_4 (μg at ℓ^{-1})	SiO_3 (μg at ℓ^{-1})
0	4.5	0.10	0.06	0.75	0.10	0.15	0.50
23	4.7	0	0	0.39	0.05	0.20	0.50
47	5.1	0	0	0.72	0	0.33	0
71	4.4	0.05	1.5	0.89	0.10	0.69	0.05
95	3.9	0	5.5	0.89	0.20	1.1	2.5
144	3.5	0	9.0	1.0	0.30	1.2	3.0
192	3.3	0	12	1.7	0.60	1.4	5.0
292	2.9	0	16	3.0	0.55	1.6	9.5
390	3.0	0	19	0.57	0.70	1.8	13
590	3.2	0	21	0.64	0.75	2.0	18
790	3.9	0	20	1.4	0.80	1.9	21
990	4.2	0	18	0.69	0.75	1.8	22

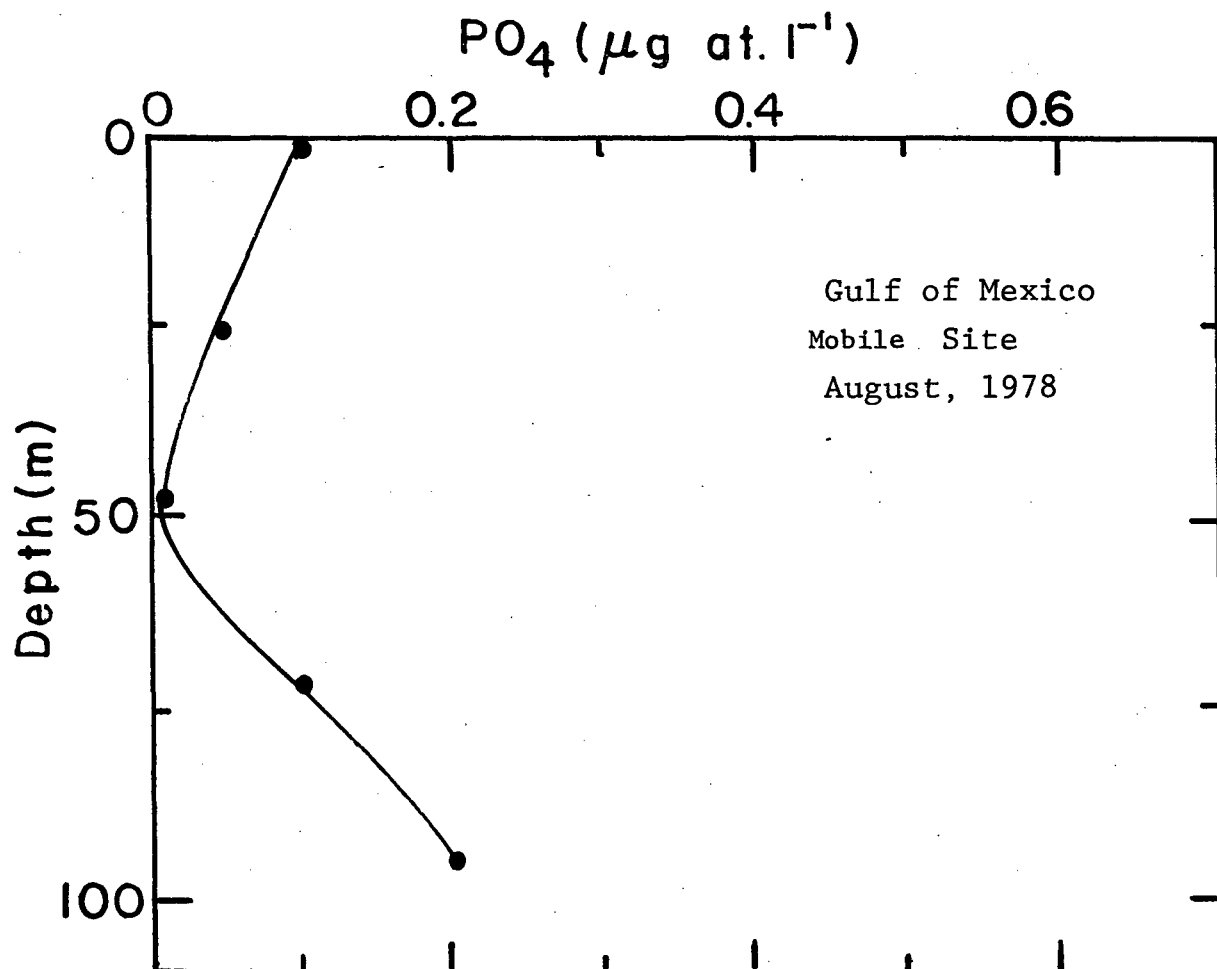


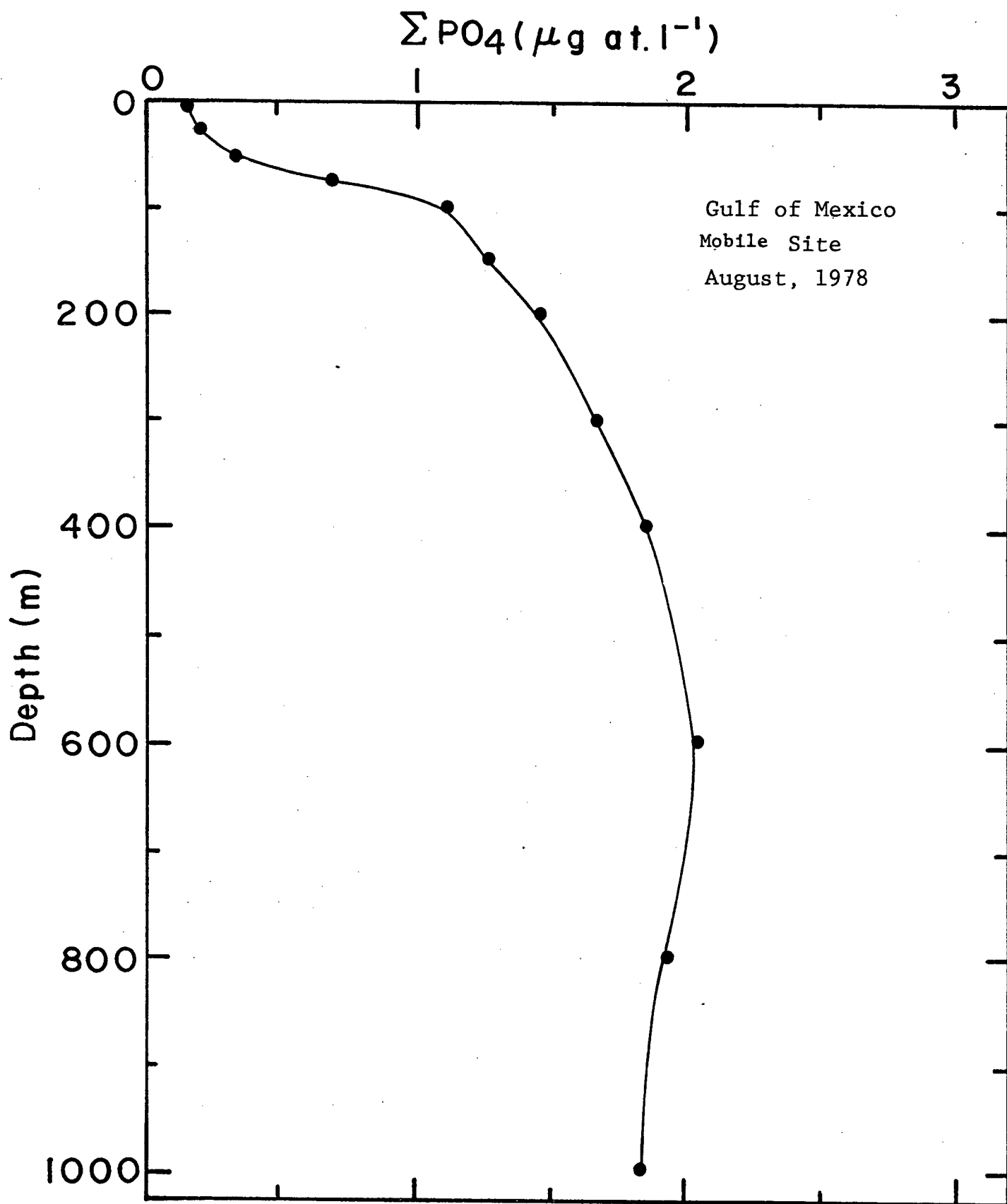


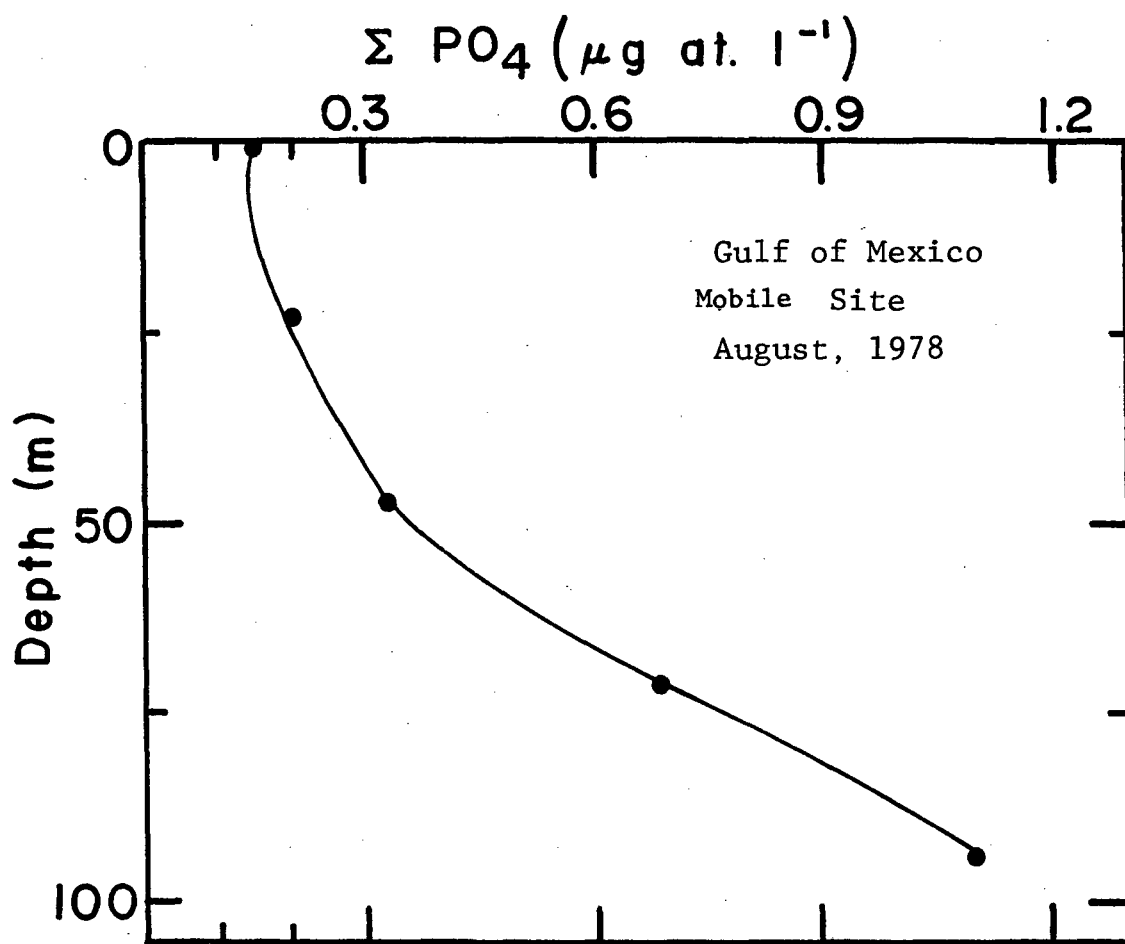


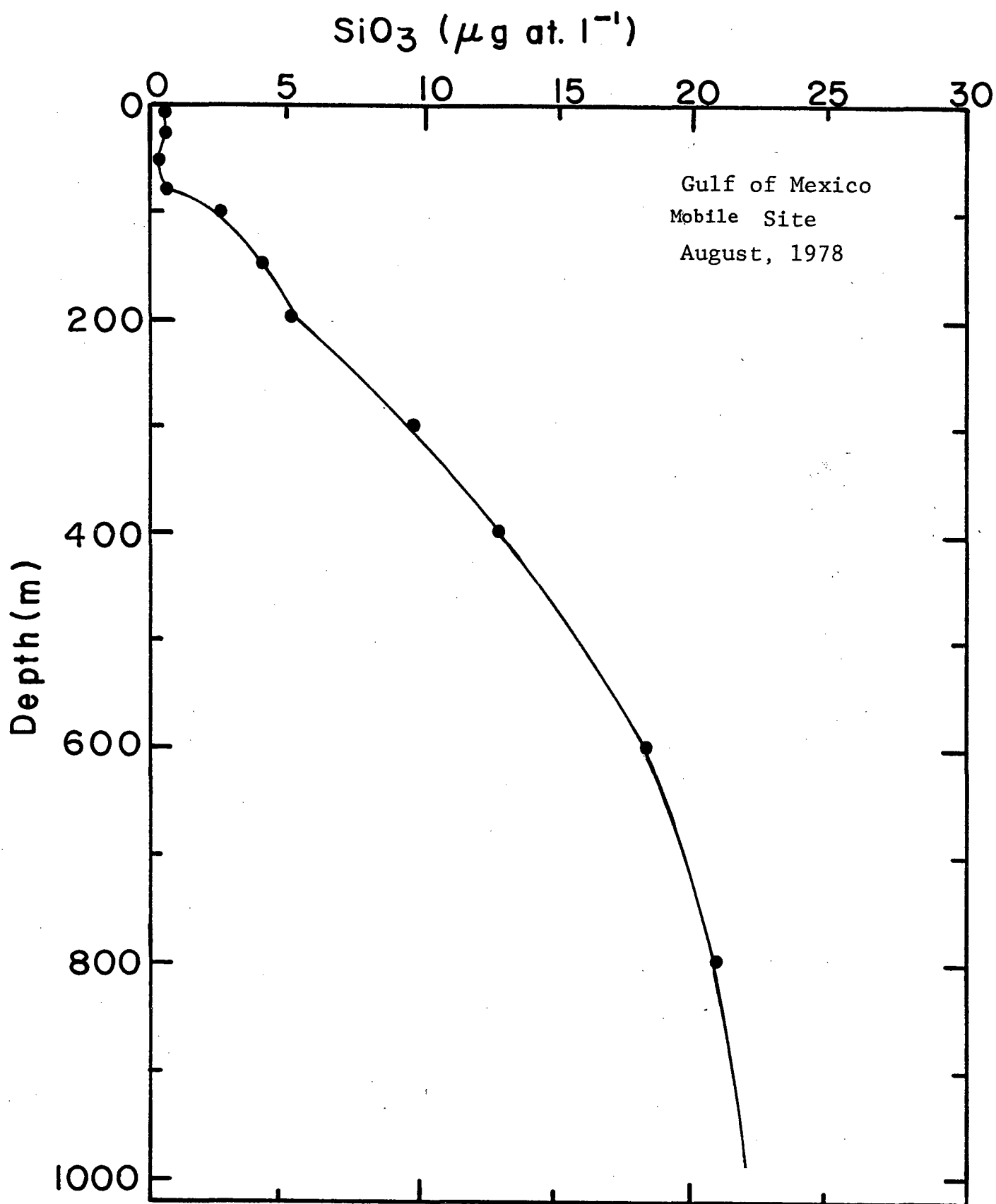


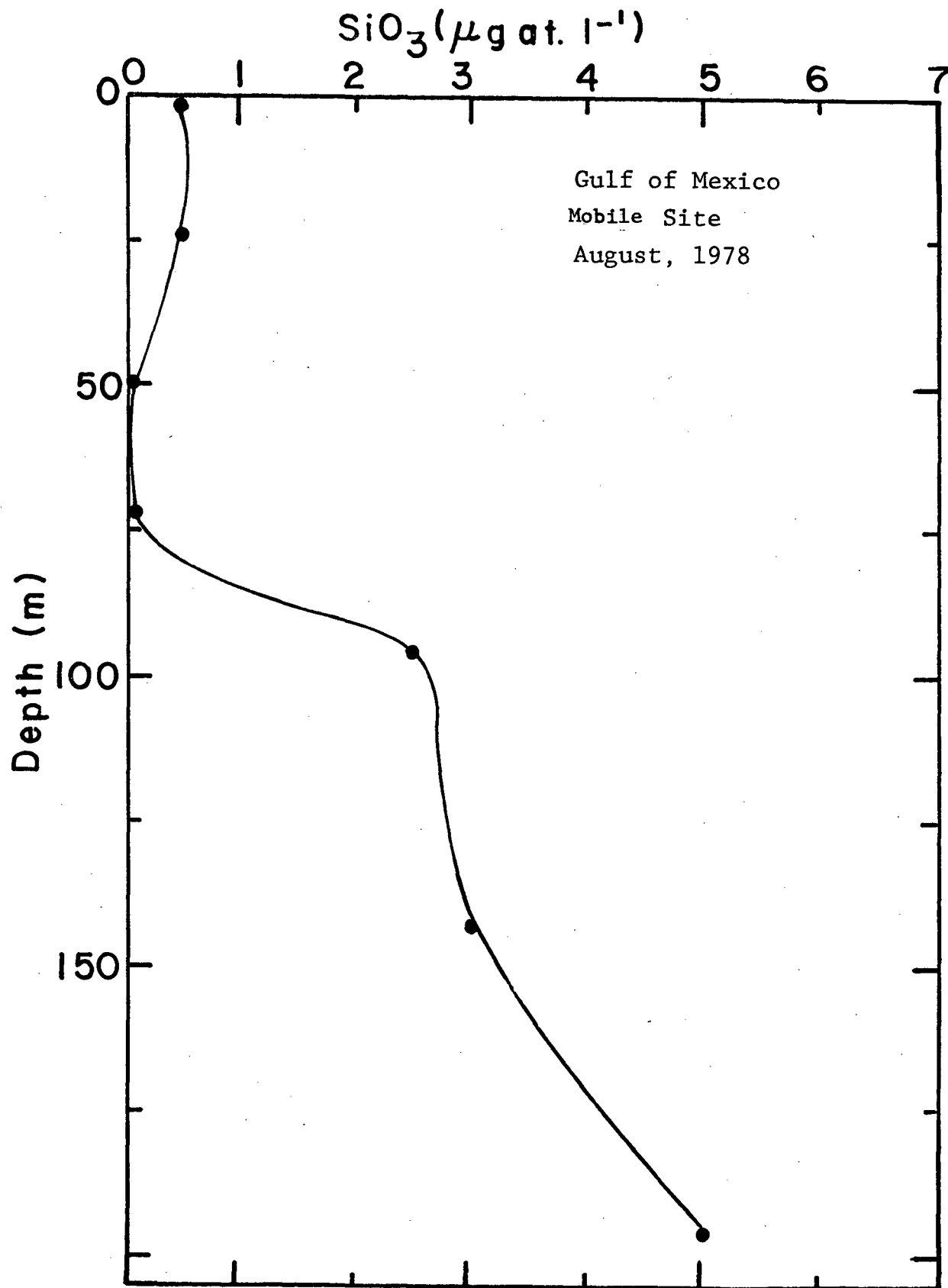












GULF OF MEXICO - MOBILE SITE

STATION 8

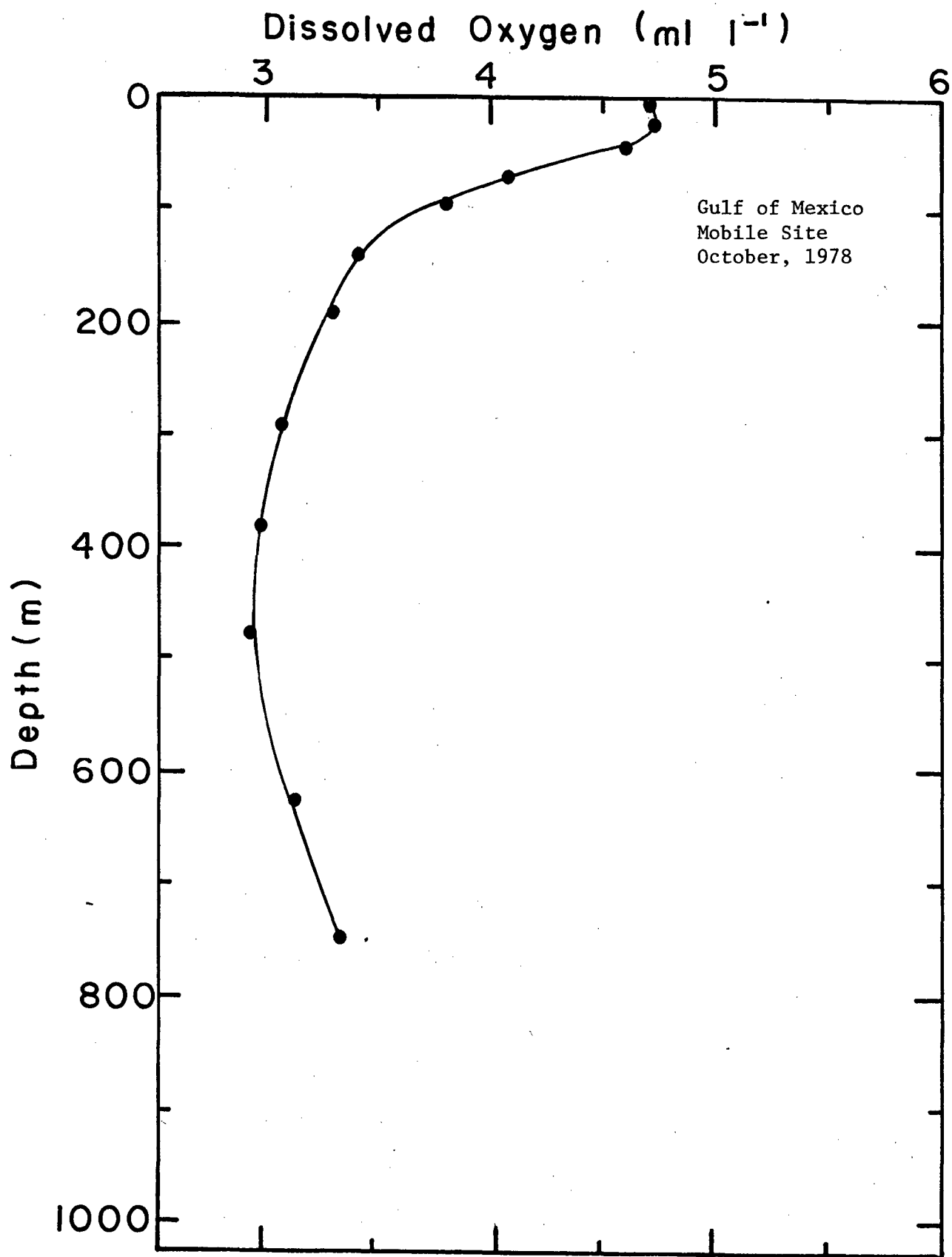
10/30/78

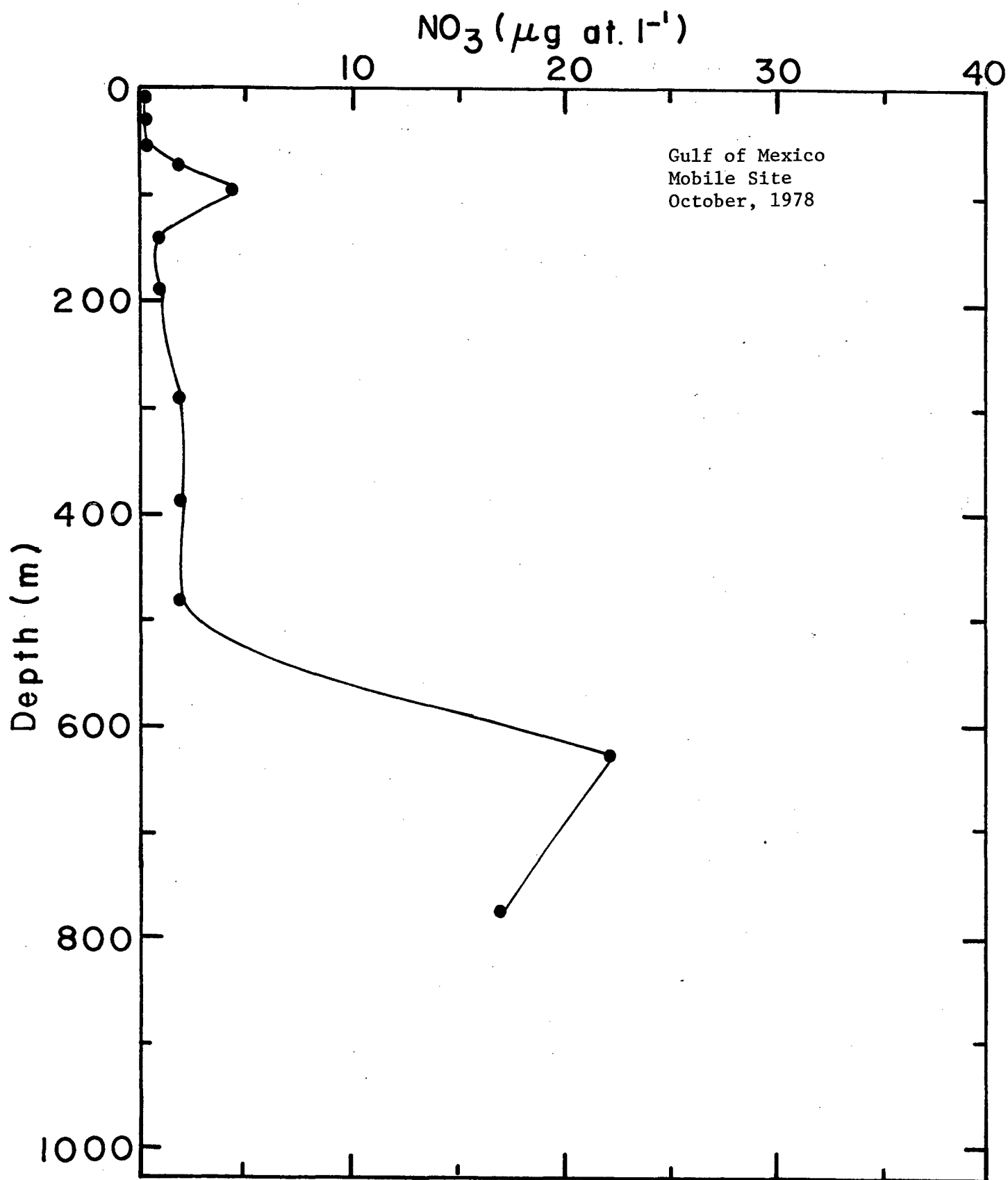
0355 Z

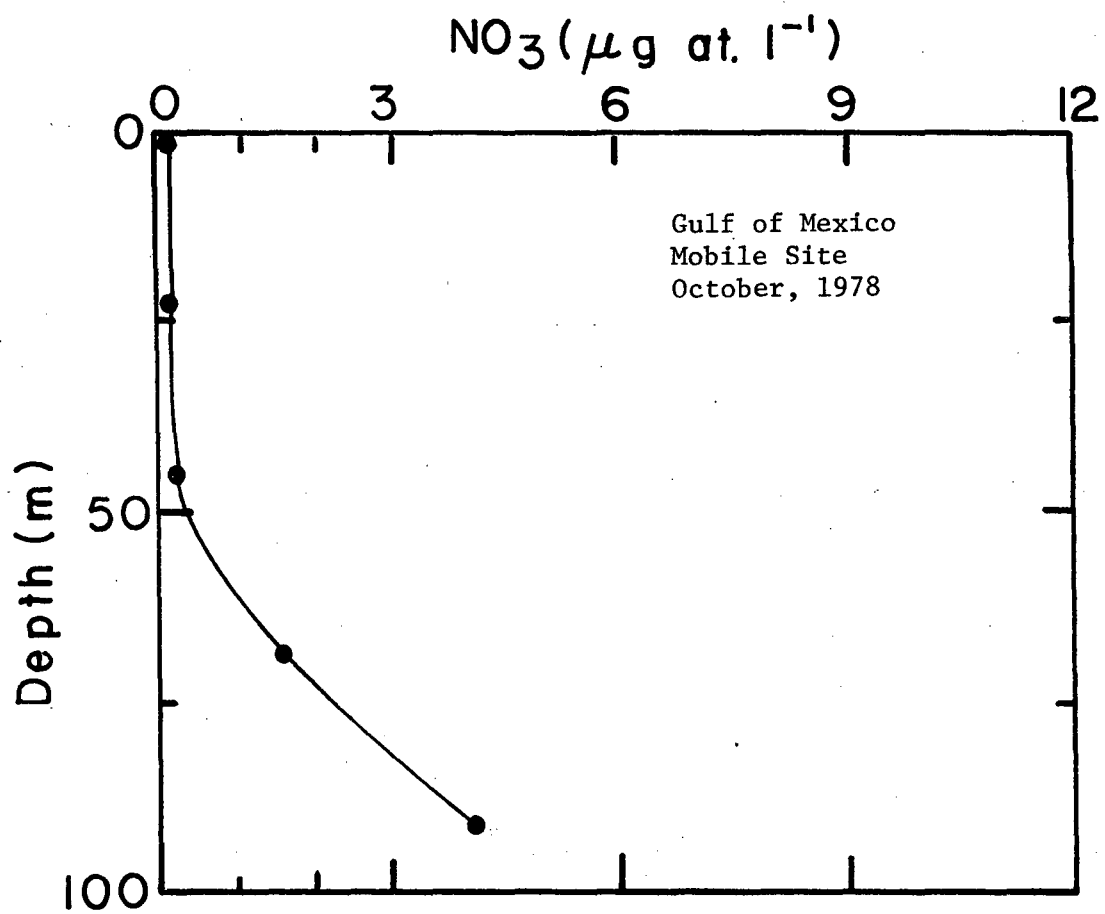
29° 11'N

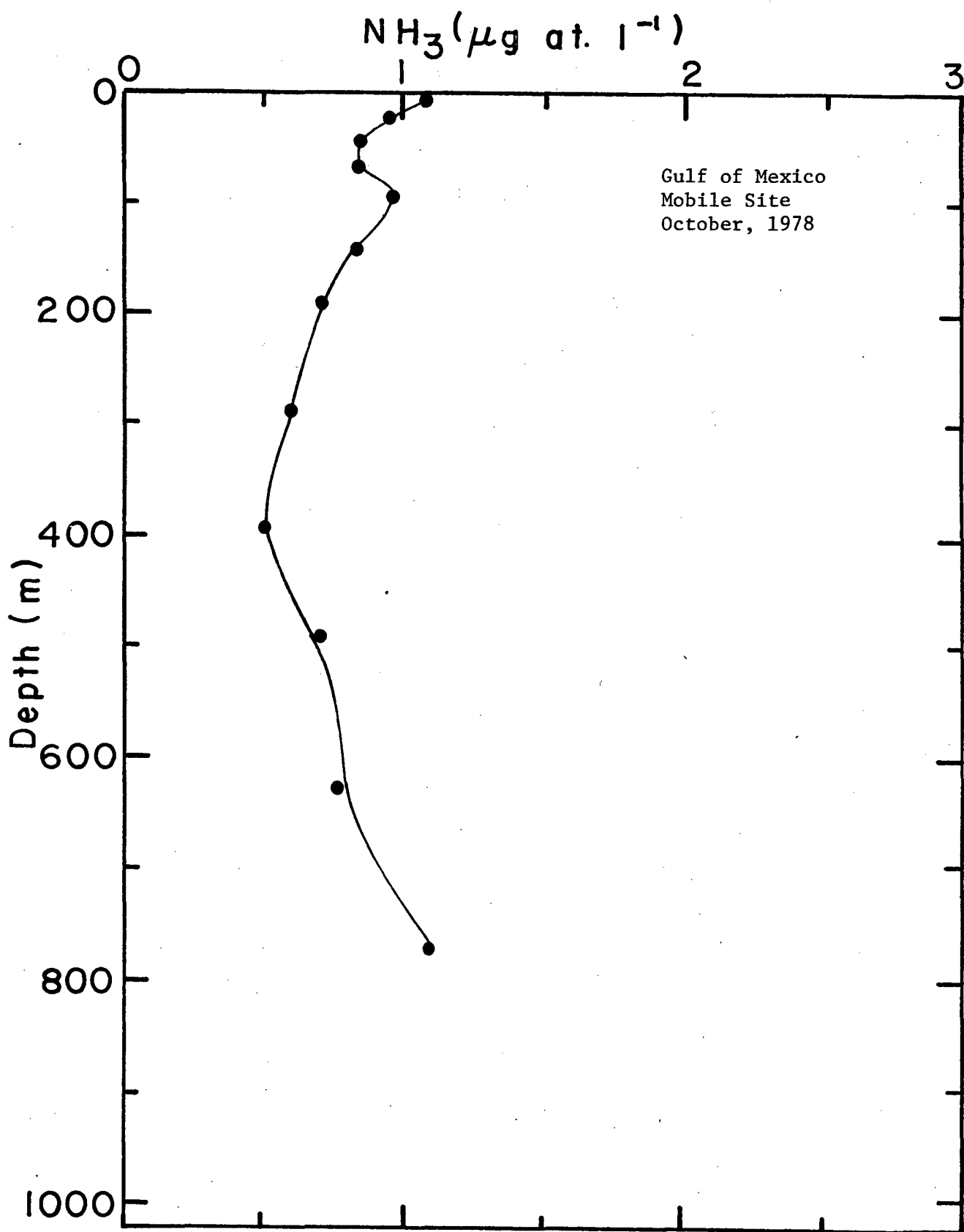
87° 39'W

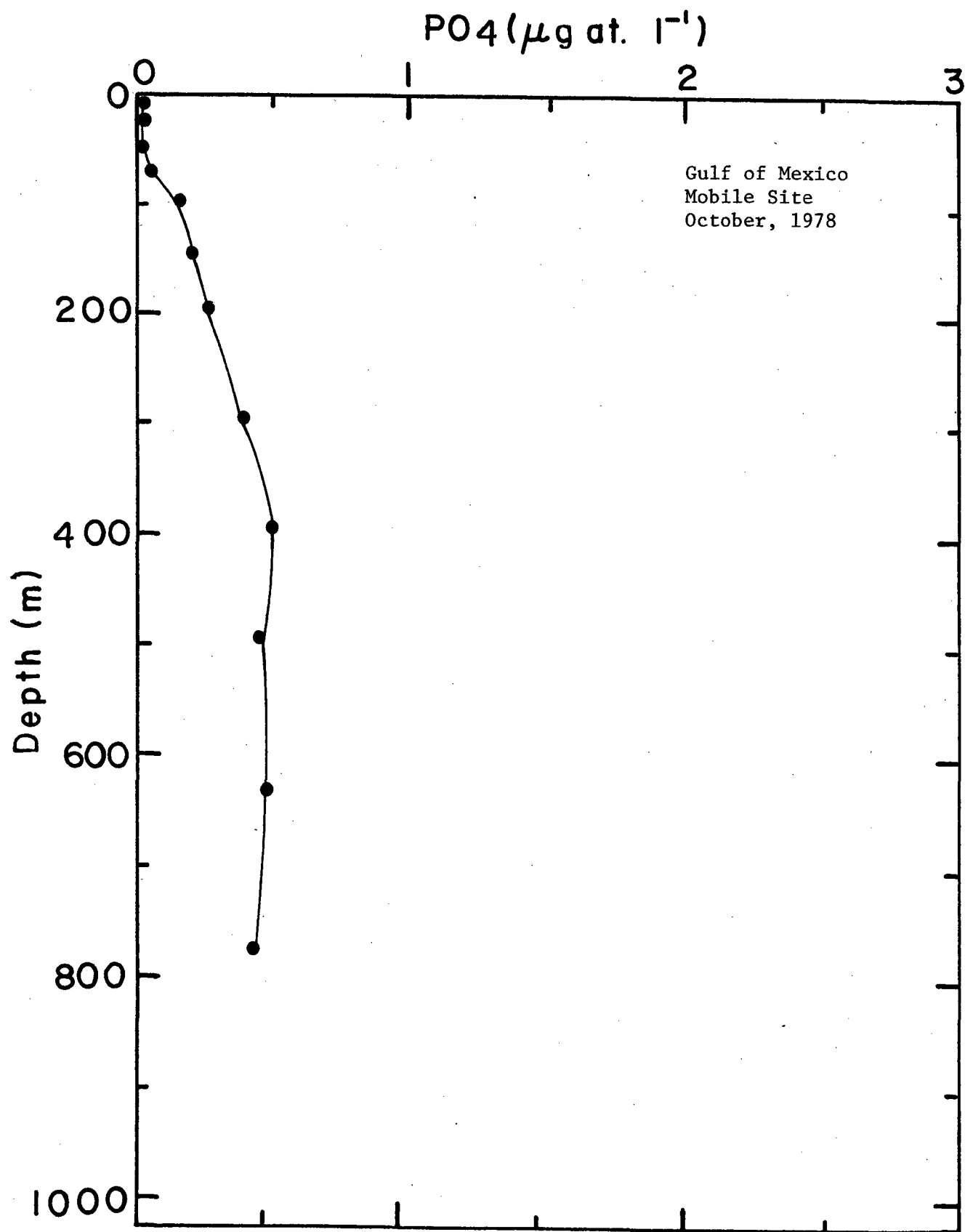
Depth (Corrected m)	O_2 (ml ℓ^{-1})	NO_2 ($\mu\text{g at } \ell^{-1}$)	NO_3 ($\mu\text{g at } \ell^{-1}$)	NH_3 ($\mu\text{g at } \ell^{-1}$)	PO_4 ($\mu\text{g at } \ell^{-1}$)	ΣPO_4 ($\mu\text{g at } \ell^{-1}$)	SiO_3 ($\mu\text{g at } \ell^{-1}$)
0	4.7	0.02	0.08	1.1	0	0.05	0
23	4.7	0.05	0.03	0.95	0	0.13	0
45	4.6	0.10	0.35	0.84	0.03	0.49	1.0
69	4.1	0.10	1.6	0.81	0.05	0.76	0.50
92	3.8	0.10	4.1	0.95	0.15	0.81	2.0
138	3.4	0.05	0.95	0.81	0.20	0.92	2.5
186	3.3	0.05	1.1	0.70	0.25	1.1	3.0
282	3.1	0.05	1.6	0.59	0.40	1.2	6.0
379	3.0	0.08	1.9	0.50	0.50	1.4	8.0
477	2.9	0.05	1.9	0.70	0.45	1.6	9.0
625	3.1	0.07	22	0.76	0.50	1.6	14
773	3.3	0.10	17	1.1	0.41	1.5	12

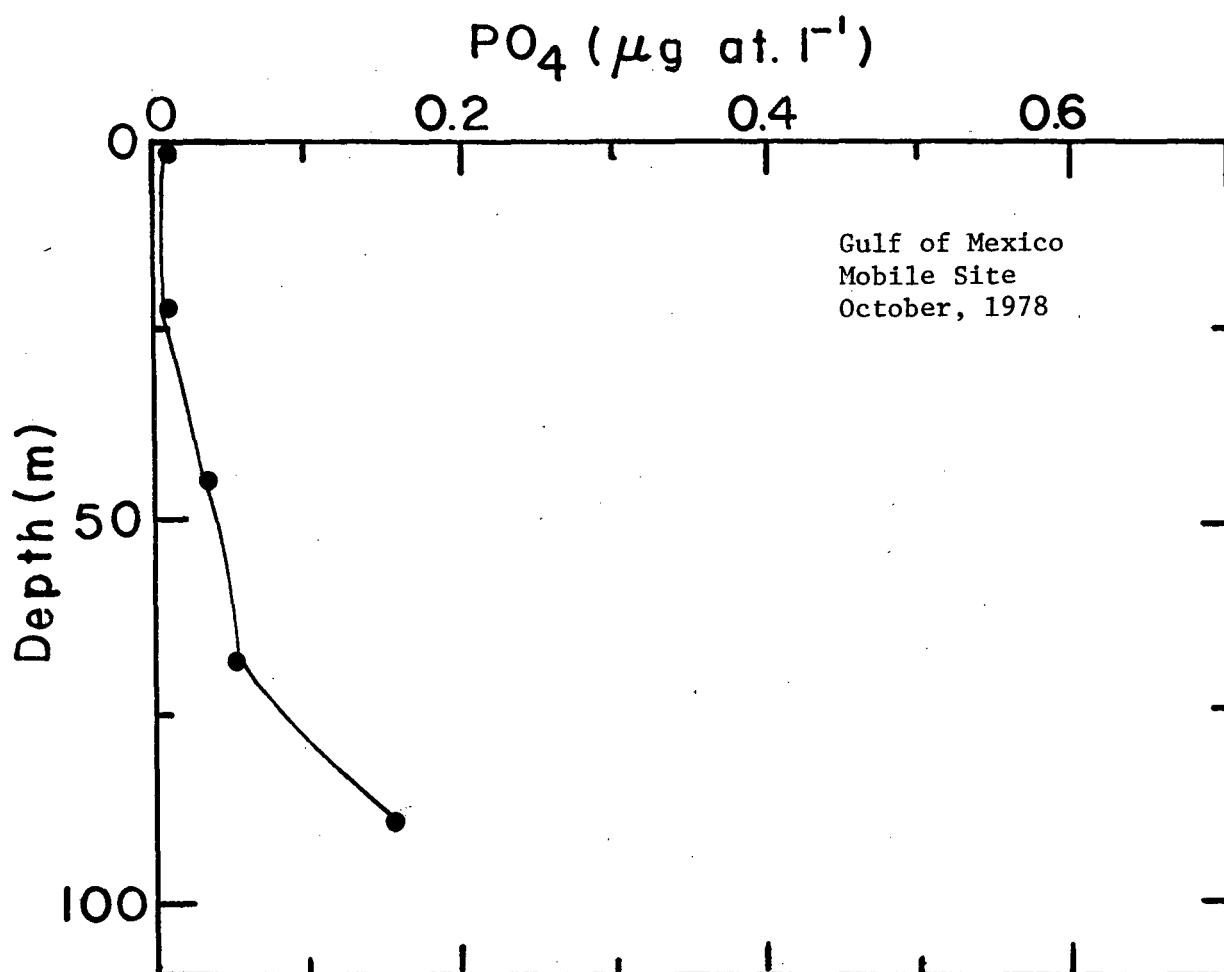


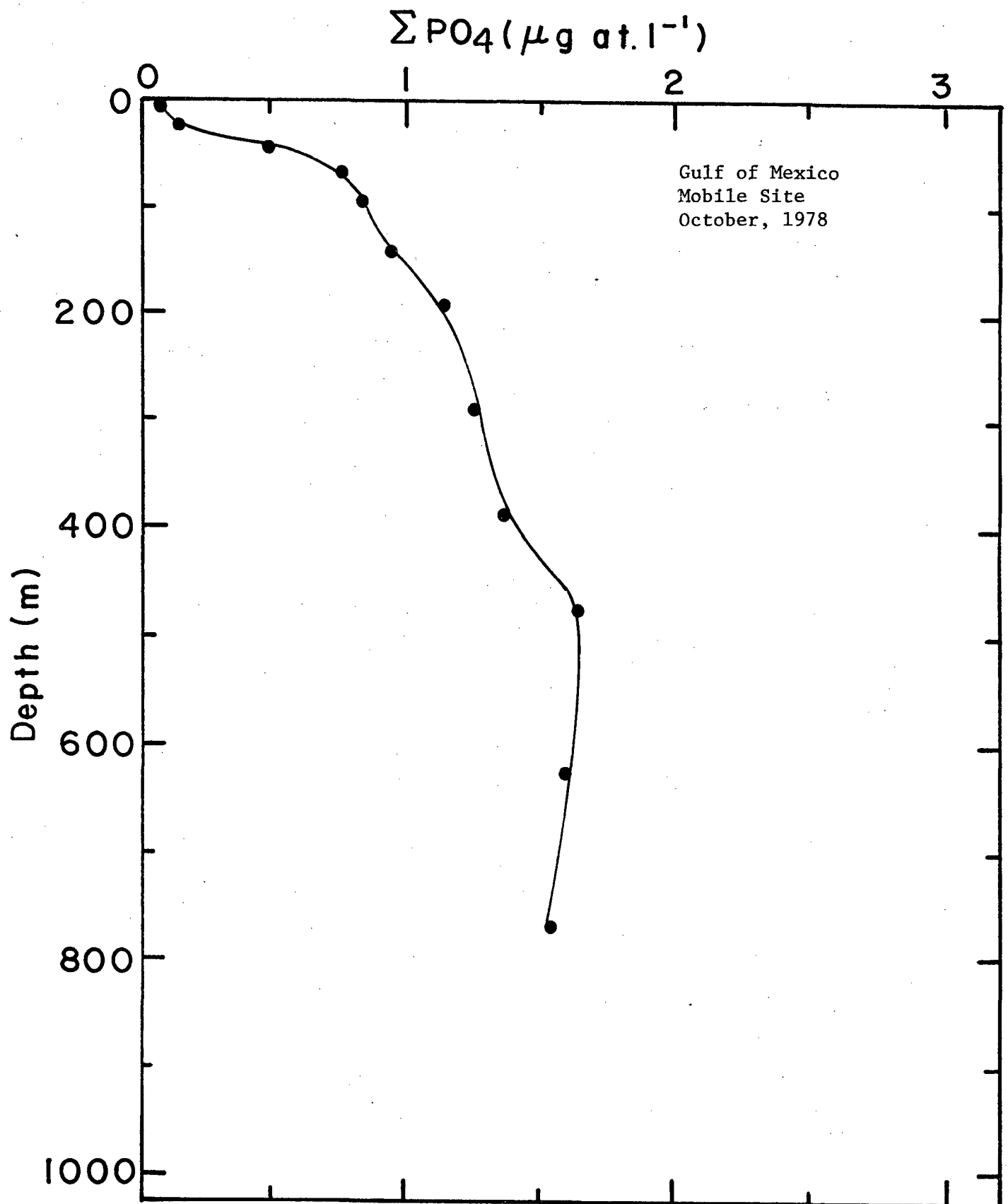


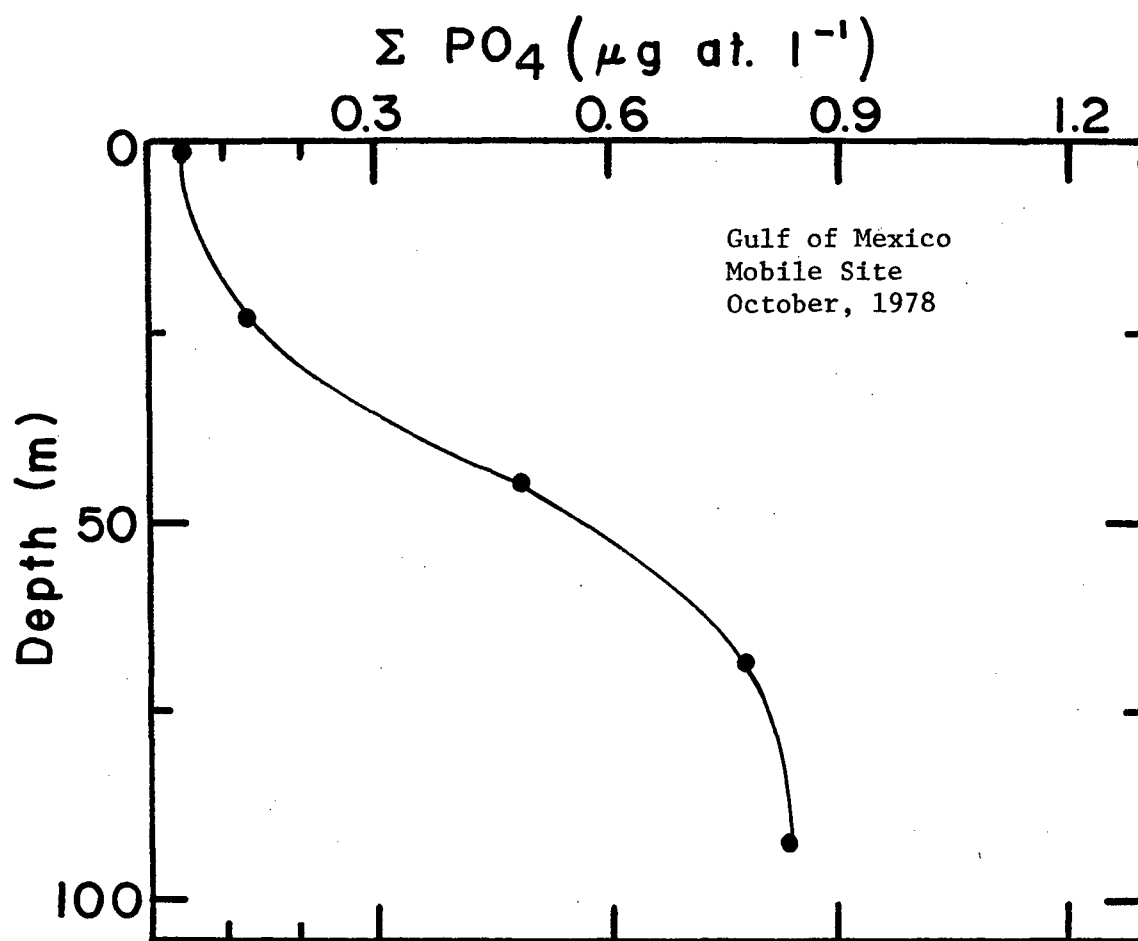


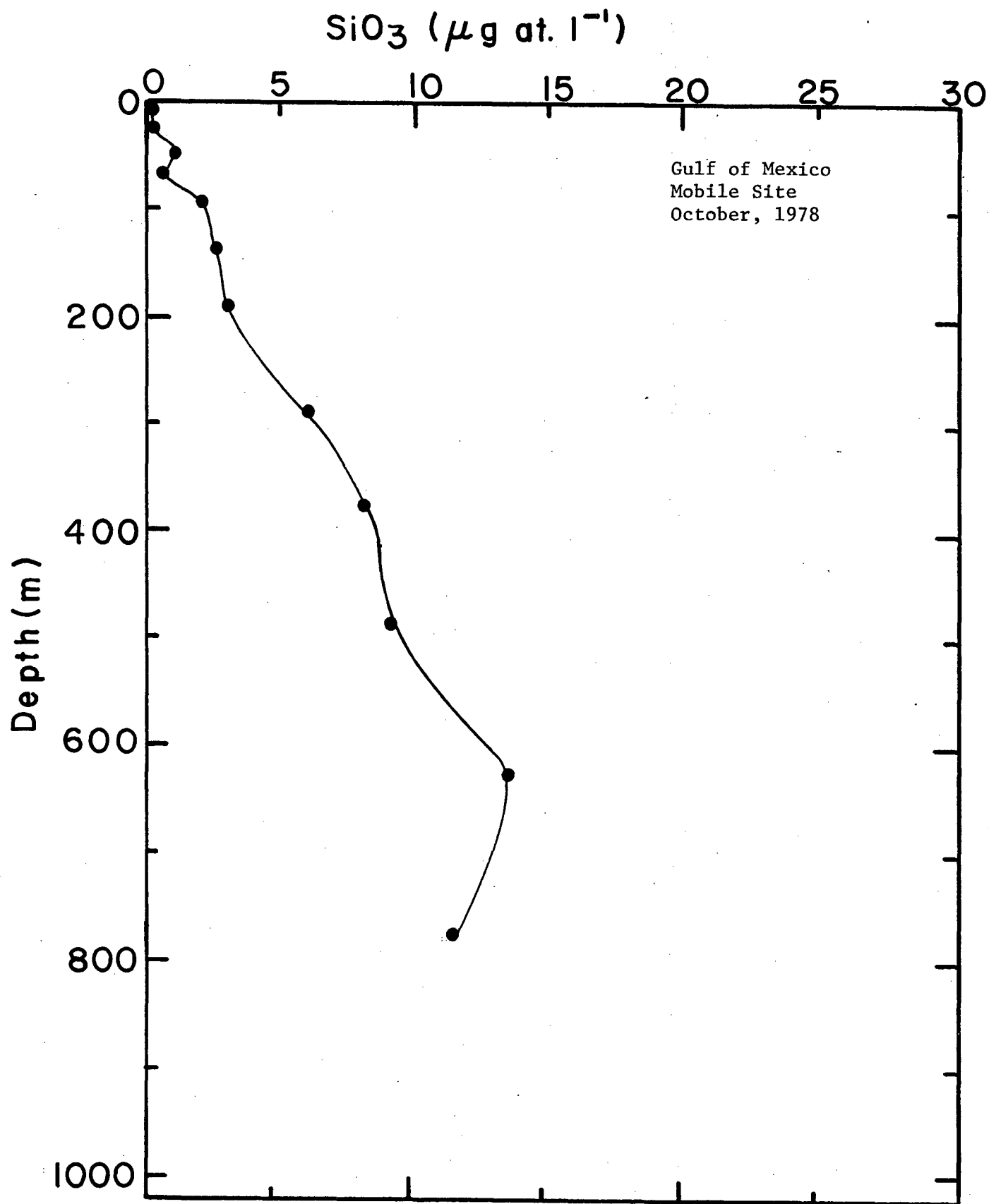


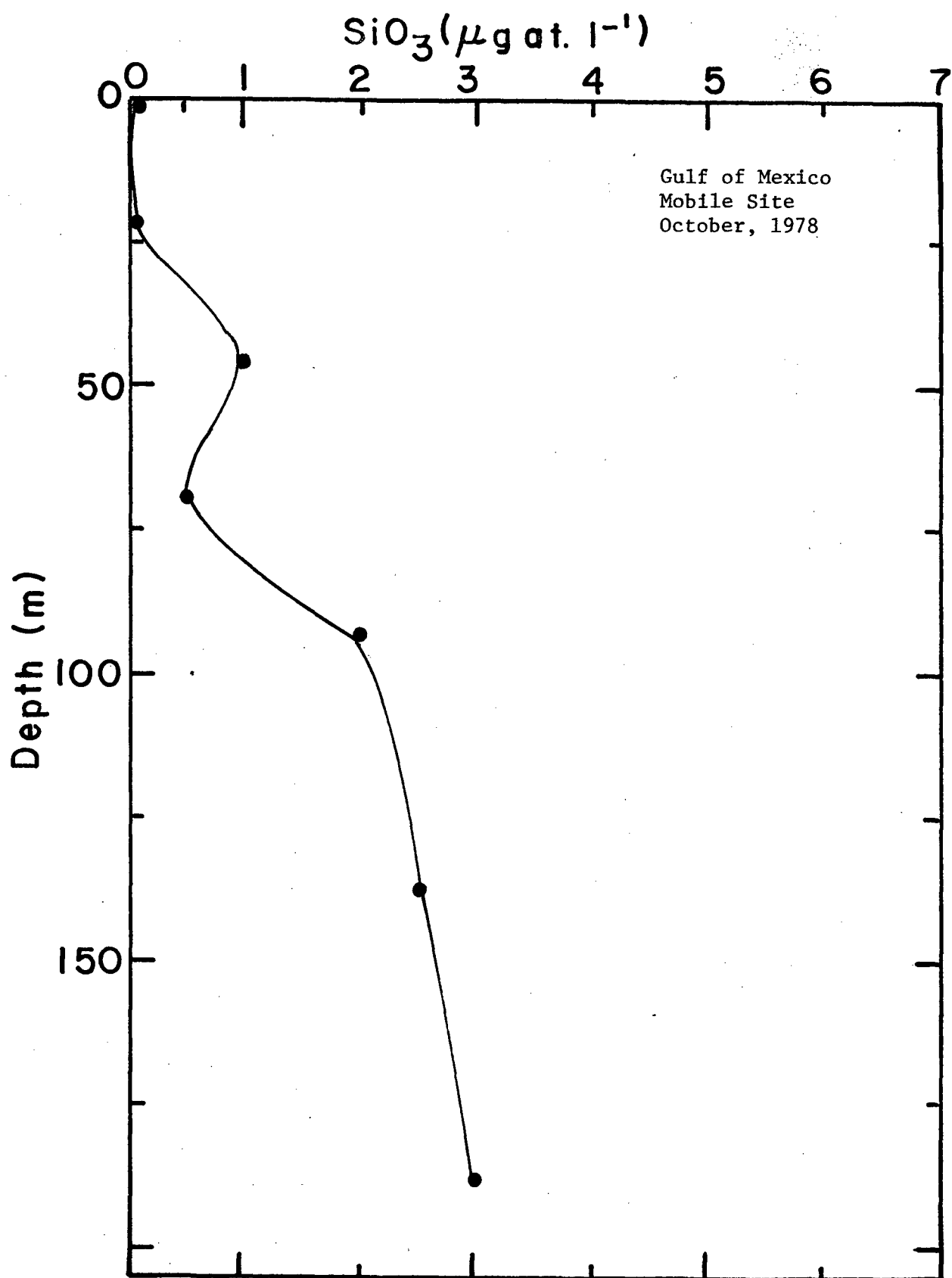










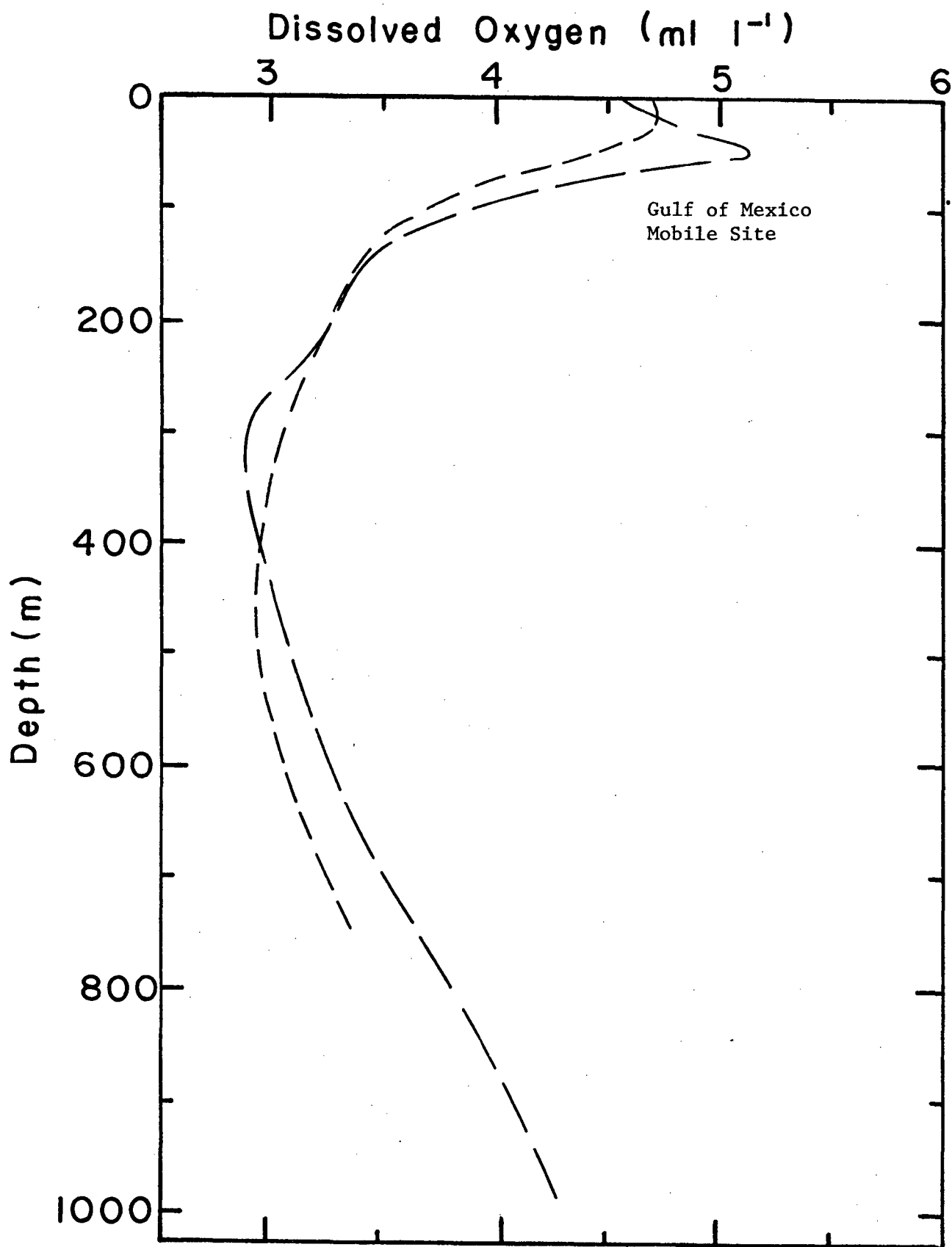


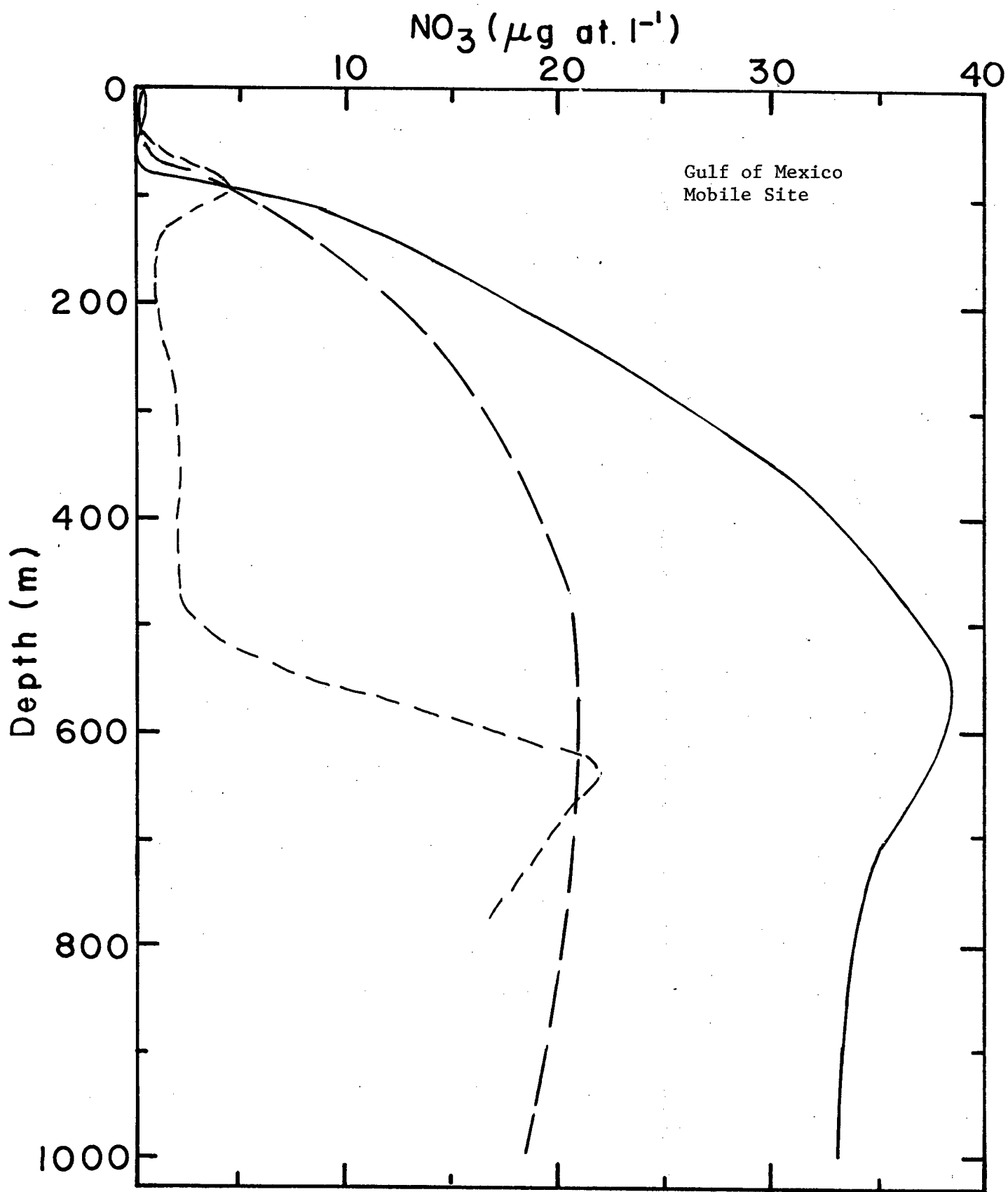
Mobile Site Composite Profiles

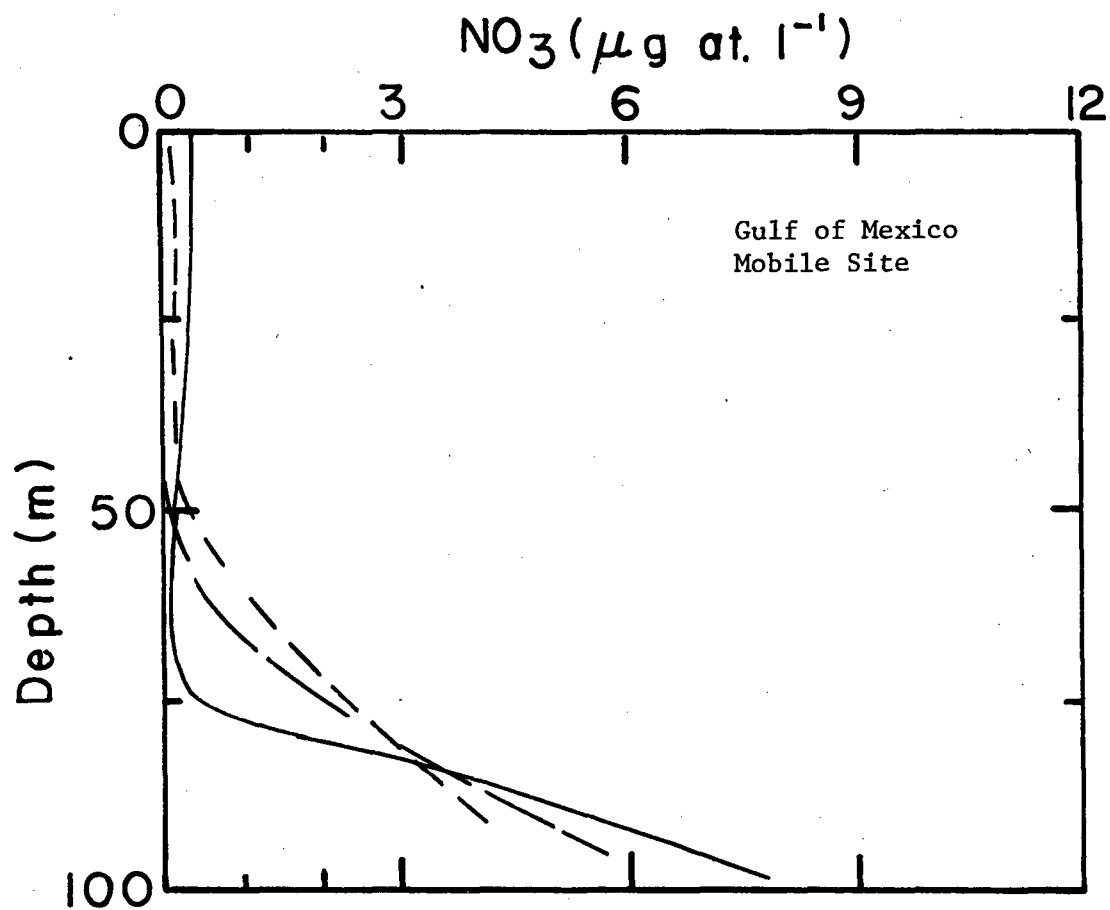
———— June, 1978

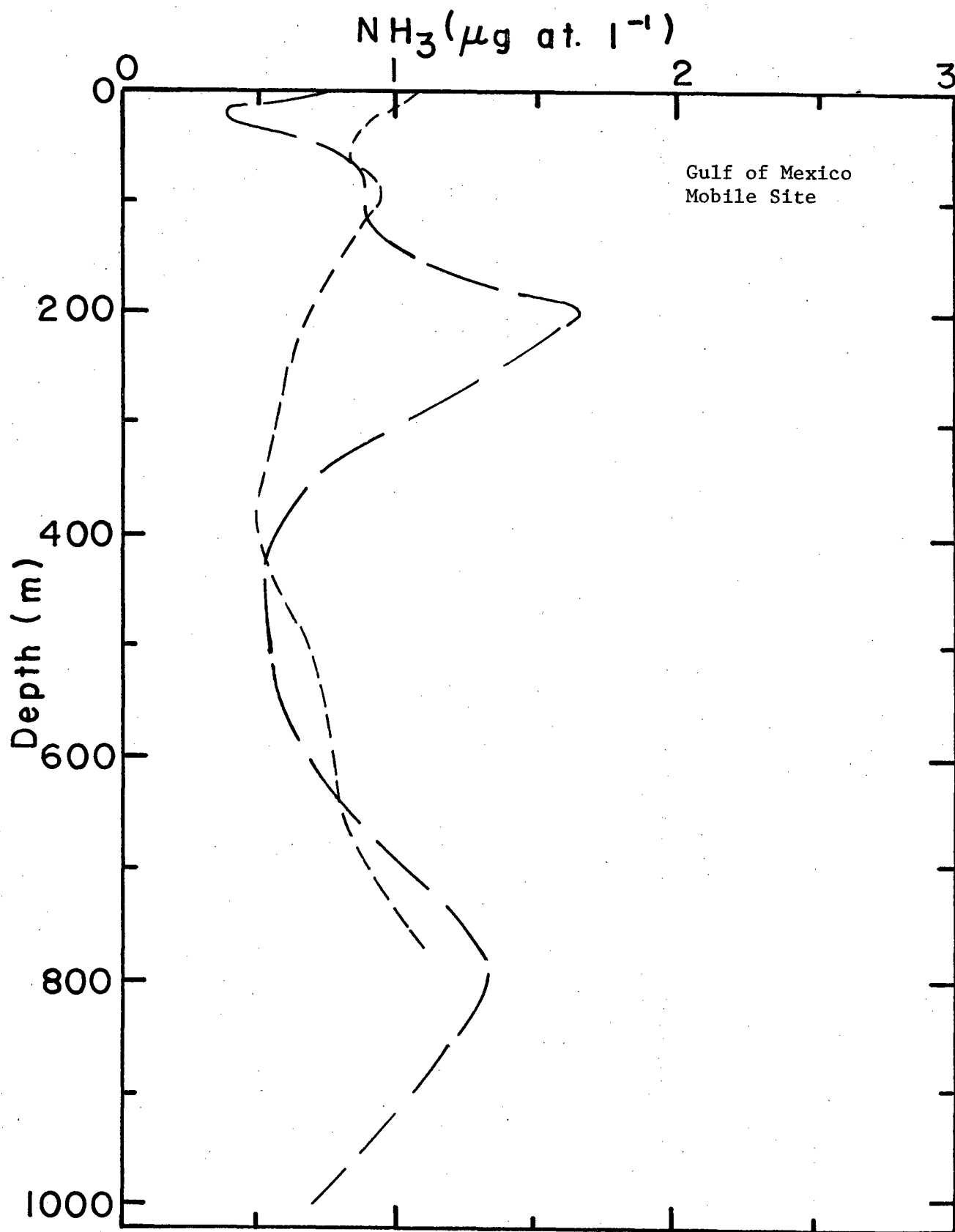
—— ——— August, 1978

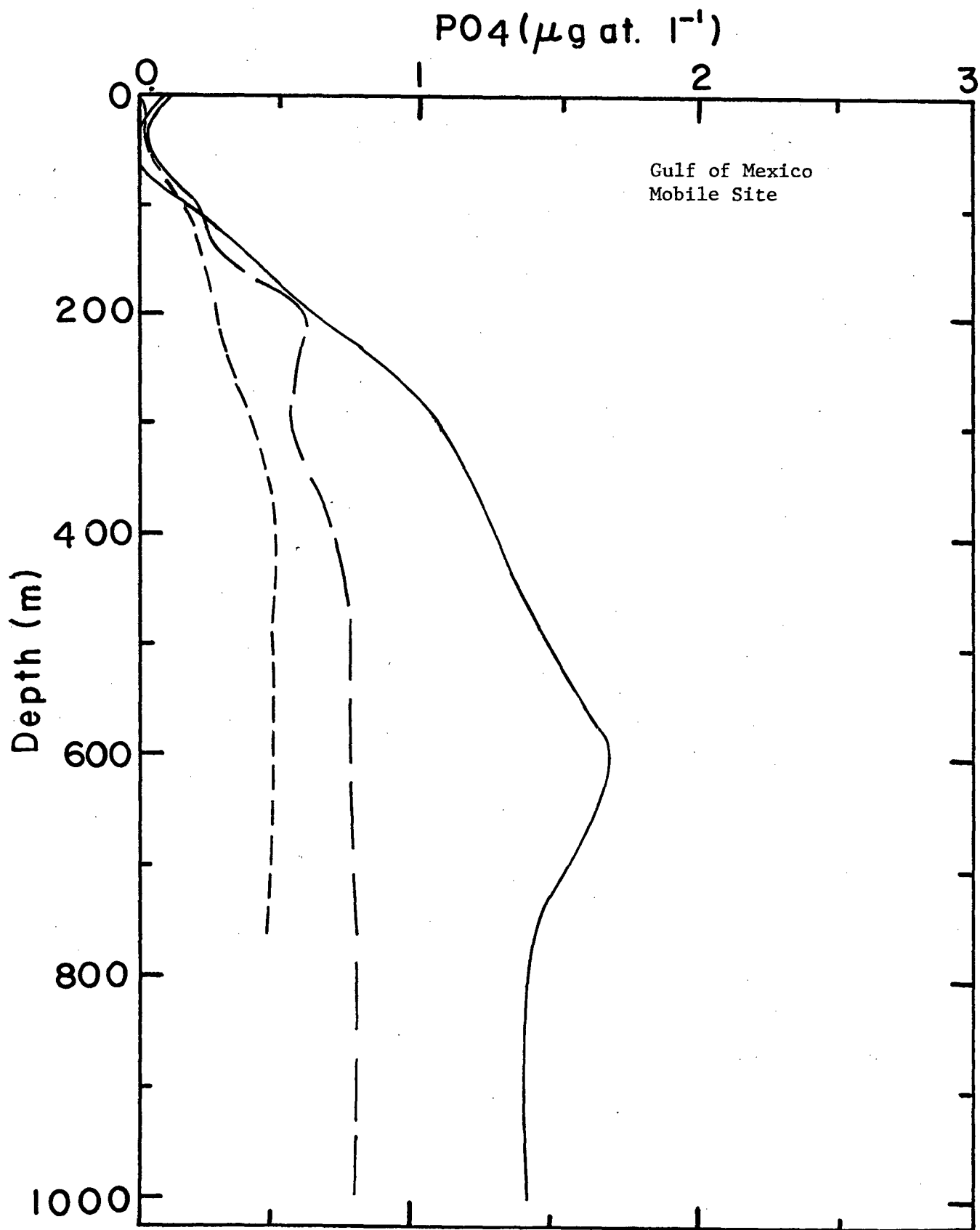
- - - - - October, 1978

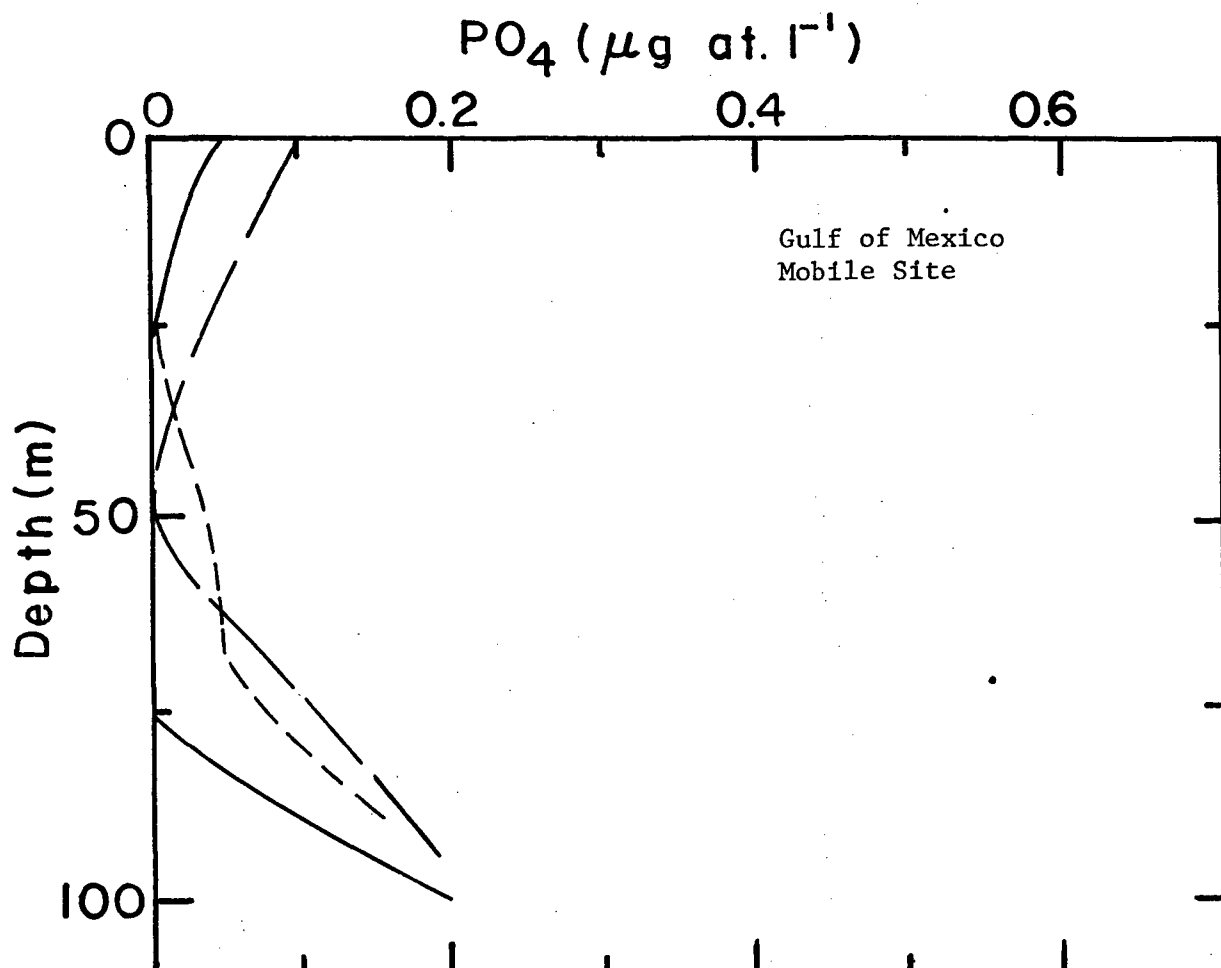


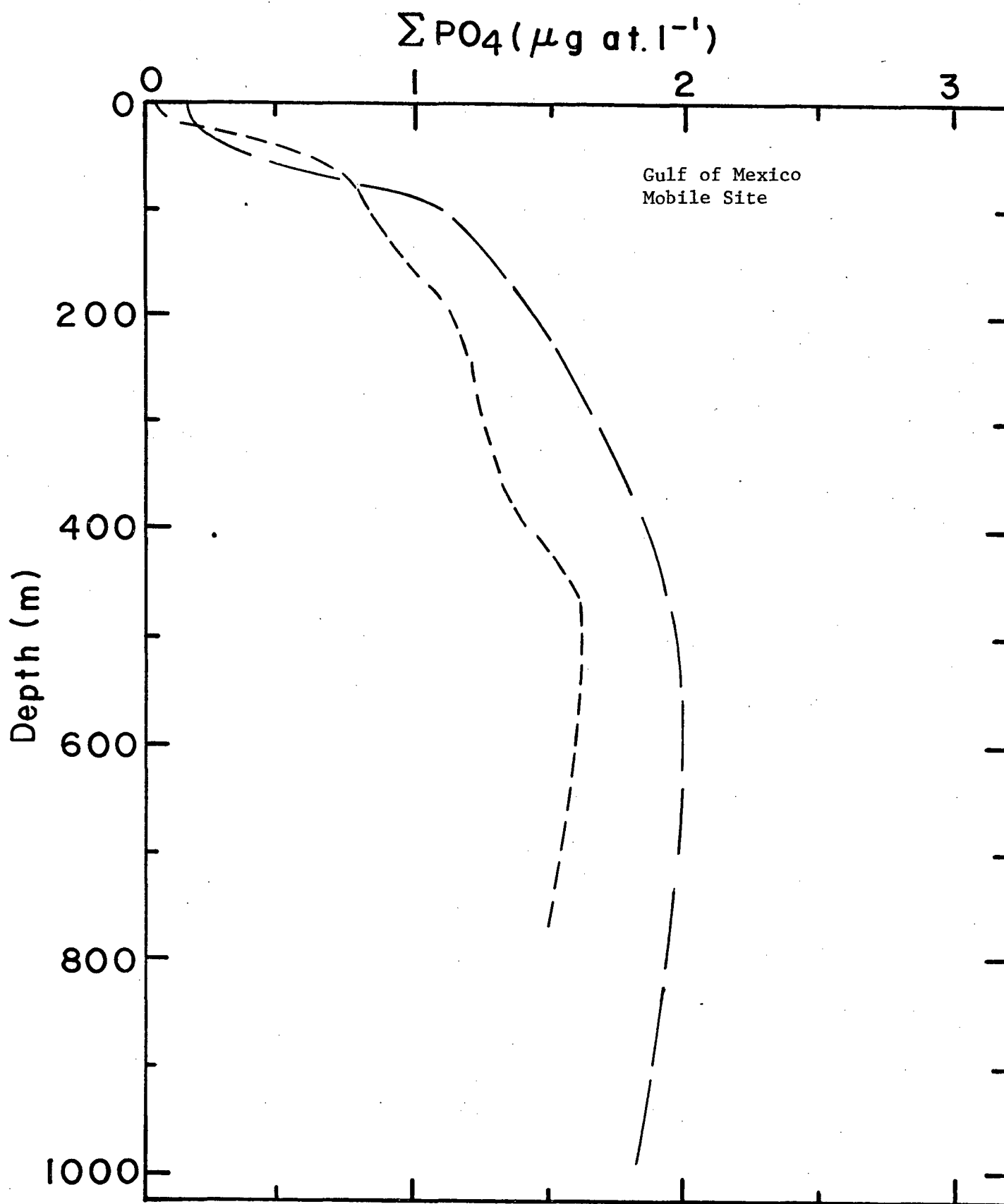


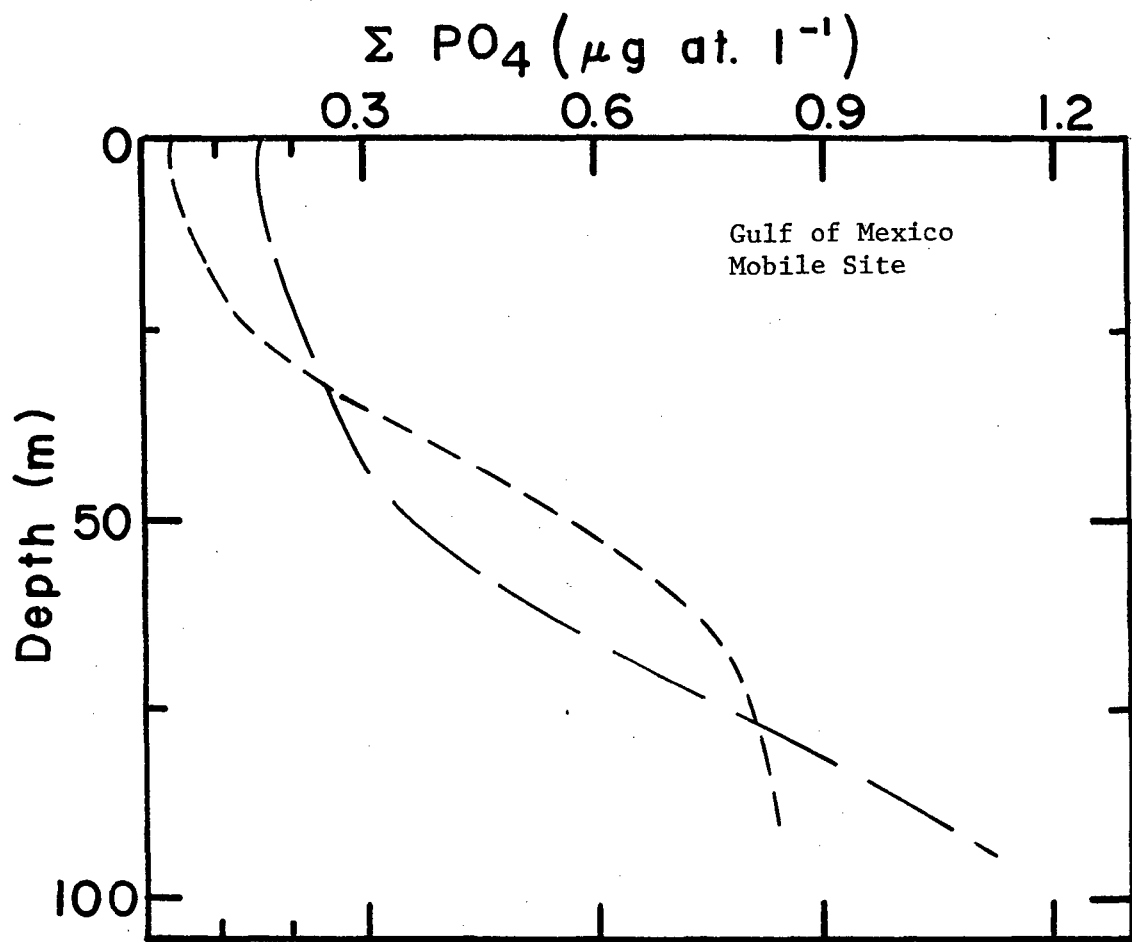


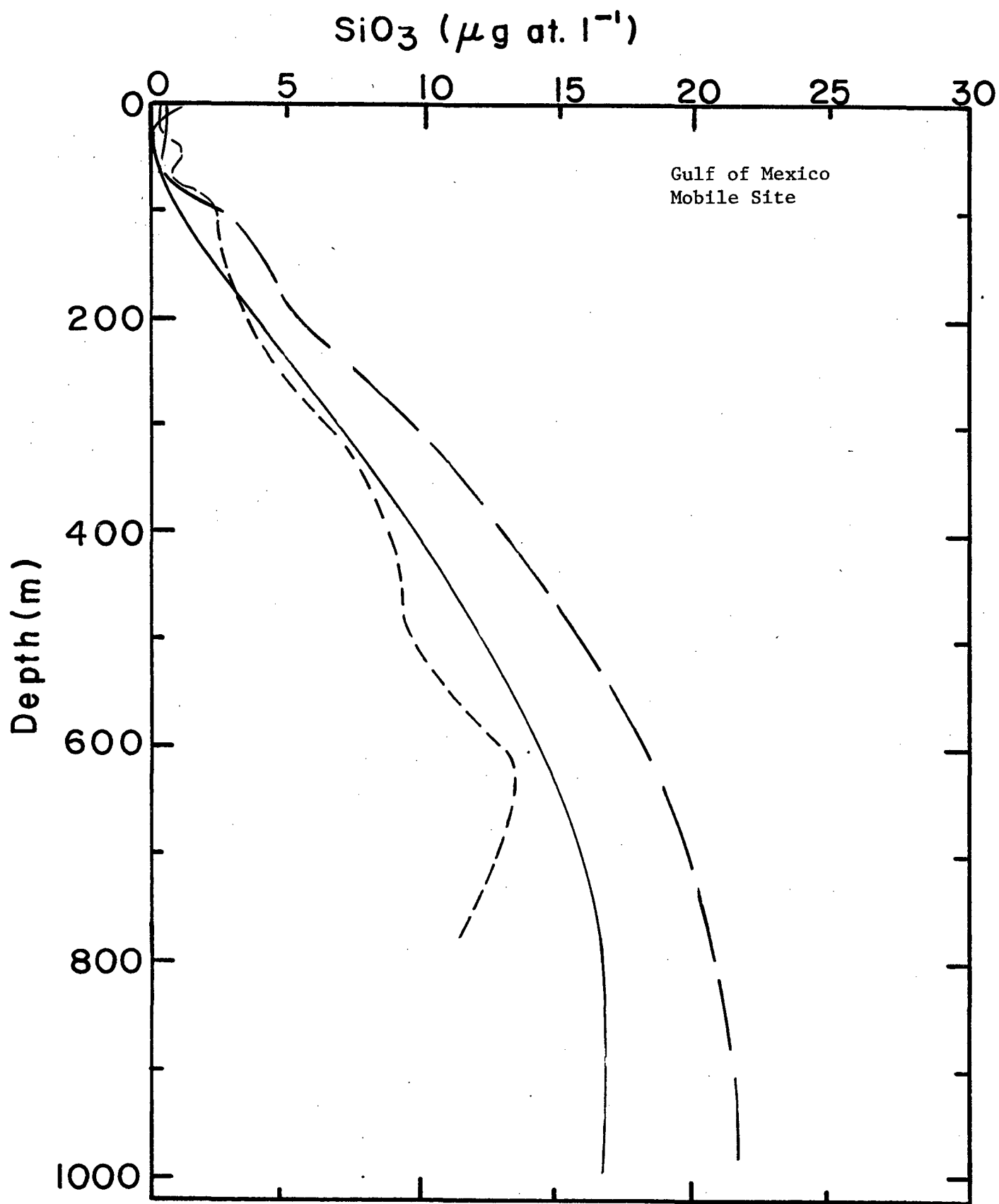


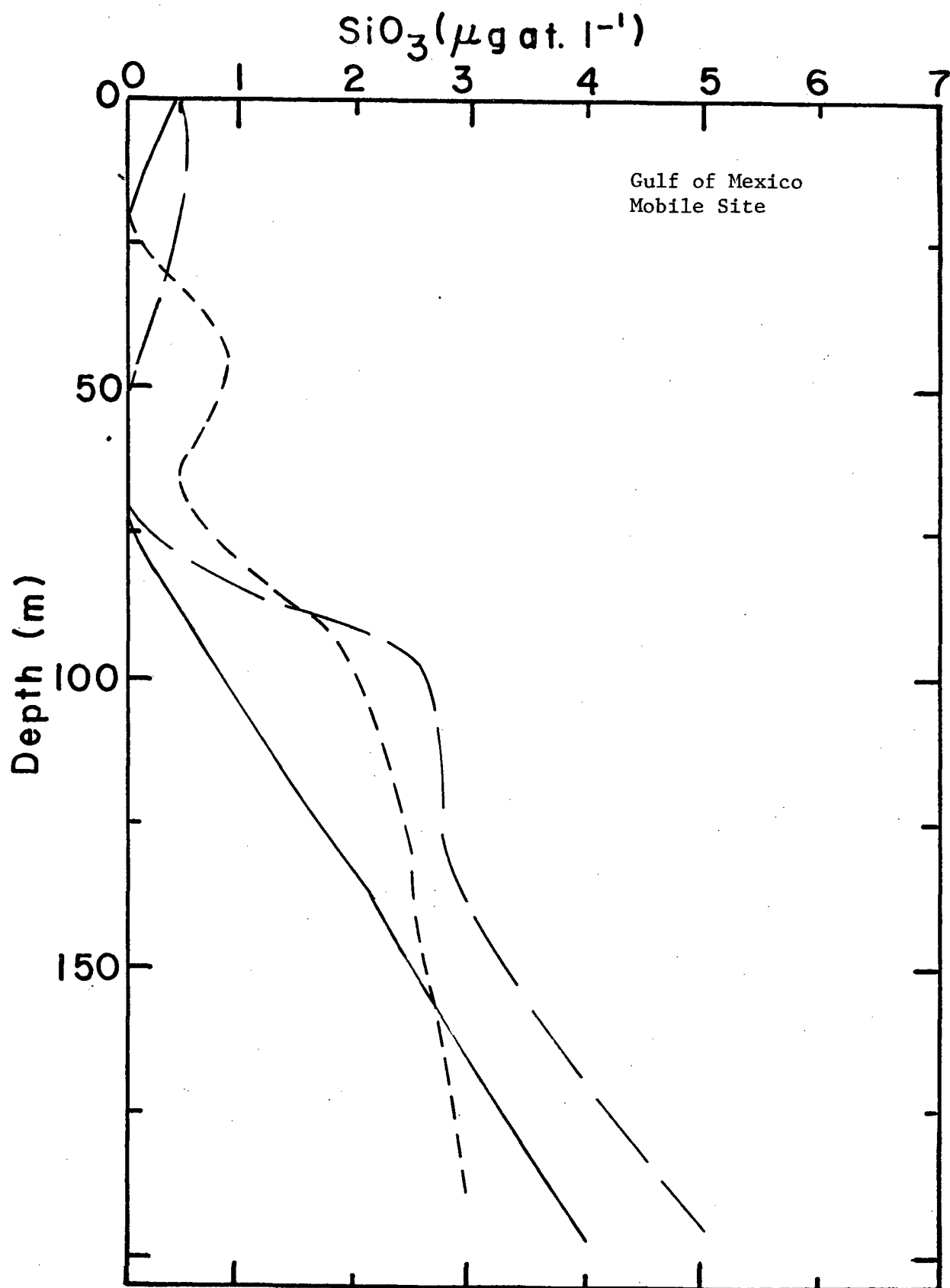












"REACTIVE" AND TOTAL PHOSPHATE COMPARISON

(Gulf of Mexico Mobile Site)

Percent of Total Phosphate Present as Reactive Phosphate

Depth (m, approx.)	June 1978	August 1978	October 1978
0	ND	67	*
25	ND	25	*
50	ND	*	6
75	ND	14	7
100	ND	18	19
150	ND	24	22
200	ND	43	22
300	ND	34	33
400	ND	38	33
600	ND	37	28
800	ND	42	32
900- 1000	ND	41	27

* Reactive PO_4 below detection limit

"REACTIVE" PHOSPHATE AND NITRATE COMPARISON

(Gulf of Mexico Mobile Site)

Depth (m, approx.)	Reactive PO ₄ : NO ₃ Ratio		
	June 1978	August 1978	October 1978
0	0.1	1.67	*
25	*	*	*
50	*	*	0.09
75	*	0.07	0.03
100	0.03	0.04	0.04
150	0.03	0.03	0.21
200	0.04	0.05	0.23
300	0.04	0.03	0.25
400	0.04	0.04	0.26
600	0.04	0.04	0.24
800	0.04	0.04	0.02
1000	0.04	0.04	0.02

* "Reactive" phosphate and/or nitrate below detection limit

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